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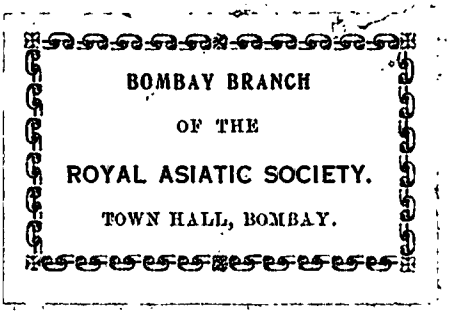

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REPORT

OF THE

Agricultural Research Institute and College, Pusa

(Including Report of the Imperial Cotton Specialist).

1907-09; 1911-12 & 1915-16

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REPORT

OF THE

Agricultural Research Institute and College, Pusa

(*Including Report of the Imperial Cotton Specialist*)

1907-09

INTRODUCTORY.

THE reports of the Director and heads of sections of the Agricultural Research Institute, Pusa, and of the Cotton Specialist for the years 1907-09, are herewith published. The period ends on the 30th June 1909.

The Institute was opened for advanced students only in July 1908. Before this 22 probationers came from various provinces for technical training in various sections, to adapt them for work of a very practical kind in the provinces concerned.

It has been definitely settled that Pusa shall chiefly be a higher teaching institution with post-graduate studies principally for selected graduates of provincial agricultural colleges and distinguished science graduates of Indian universities. Arrangements have, however, been made, for the time being, to give in agriculture, economic botany and entomology, short courses particularly in regard to the practical application of these sciences to every-day agriculture or horticulture in India. I attach great value

to these practical courses. A prospectus of the Pusa College has, for general information, been published.

Before I review in short detail the work done at Pusa, there are a few features of this Institute which I wish to clearly define. The first refers to the general suitability of Pusa for the central research and experimental station for the whole of India. Pusa is a magnificent estate of over 1,300 acres, bounded on three sides by a loop of the little Gundak river. The soil is deep alluvial and is capable of growing successfully nearly every rain crop which can be grown in the plains of India. With irrigation from wells or from the river, it can grow successfully the majority of the more important garden crops. We have arranged for all necessary means of irrigation from the river and from wells, also for dealing with many important crops. The rainfall of Pusa and of Behar is generally secure; otherwise the district could not maintain its population of 900 to 1,100 per square mile. Pusa is situated in the heart of intensive agriculture which is largely controlled by a community of indigo planters. Agricultural improvements through their influence, can be brought to the notice of ordinary cultivators in a manner which is unique for other parts of India. This was one reason why Pusa was selected as the central research station. Mr. Coventry, an experienced indigo planter and an extensive experimentor in agricultural problems, was selected as the Director. He has very particular opportunities of spreading very far afield the results of the research work and of the practical field enquiries which are undertaken at Pusa.

We have at Pusa the Phipps' laboratory, a two-storied building, well-equipped with a laboratory for each branch of agricultural science and a physical laboratory. The main building also includes a library, museums for the various sections and the necessary lecture rooms. Quarters have been provided for the European and Indian staffs. There are recreation grounds, and I am glad to

say that the European staff, assistants and students are keen on sports. A hostel with accommodation for 70 students is provided, also a well-equipped hospital and dispensary.

All sections were very badly housed at Pusa in temporary laboratories for some time. The head of each section now rejoices in having a well-equipped laboratory with all necessary fittings and apparatus. The Institute is served by water-power and electric installations.

The amenities of the estate have been much improved in many ways. A new approach avenue to the Institute has been constructed, and the lawns surrounding the college building have been laid out under irrigation and sparsely planted parklike with trees and ornamental shrubs. The scrub and jungle growth on the estate has been mostly cleared, thus making preparation for bringing waste land under cultivation. The unsightly brick-fields near the entrance to the estate, have been levelled and are now under cultivation with suitable ordinary crops. An area of some 150 acres has been reclaimed for arable cultivation. Practically the whole of the estate is now under grass or cultivation.

It has been proved in the past that the Pusa estate is capable of growing very fine timber trees in the avenues and elsewhere; consequently we are endeavouring to improve the attractiveness of the estate by planting and protecting young trees in the pasture areas, along the frontage of the river and in the avenues. The existing teak, shishum, bamboo, and mahogany avenues are an object lesson to many parts of India. We even expect to improve upon these. The fruit orchards and botanical area are now attractive features. A large vegetable garden is maintained. Many suitable trees on the riverside land have been inoculated with lac.

Nineteen students in all the various sections were admitted for training in 1908-09. In regard to the scientific and practical teaching in the lecture rooms, in the laboratories and in the fields at Pusa, my chief desire is that it

should be a means of helping, in a very practical way, the ordinary or improved agriculture of this country. I wish, therefore, to attract, from provincial agricultural colleges and from other colleges, students of high class ability who have been reared on the land.

Many of such students are usually poor and cannot afford the expense of an advanced course in research work. Government have spent of late years large sums on the development of agriculture, and I am confident that Indian gentlemen generally interested in the work will do their share. There is perhaps no direction in which there is more scope for liberality of the most useful kind than in the founding of scholarships for students at Pusa.

I refer below to some of the work done in each section at Pusa and by the Cotton Specialist. A full review of each report is not required here.

Agriculture.—Mr. E. Shearer, Imperial Agriculturist, has done much useful work for the Department. He was absent on privilege leave from 2nd July to 30th September 1908, when his duties were carried on by the Director.

Permanent manurial and rotation experiments were laid down last year on two blocks of 9 acres each. The land selected for these experiments has been tested and found sufficiently uniform for the purpose.

Permanent pasture experiments were laid down in the monsoon of 1907. It is very important to know the best conditions in various parts of India under which pastures can, on practical lines, be properly established and improved. This is the aim of the Pusa experiments, and it is believed that the results will be of very wide application, especially as similar grass experiments have been undertaken in some provinces. Already there is a decided change in the character of the herbage in some of the manured plots at Pusa.

Arable areas which are likely to be suitable for the extension of experimental work in the future, are being treated uniformly in regard to cultivation and cropping.

The more important crops under trial at Pusa include wheat, barley, oats, maize, rice, various pulses, oil-seeds, sugarcane, jute, flax, and tobacco. Efforts are being made to obtain and acclimatise the best indigenous and foreign varieties of these crops. Cotton varieties have been given up, as nearly all are unsuitable to Behar.

Perhaps the most important line of work in the Agricutural Section at Pusa, refers to the breeding and rearing of farm live stock. A very select herd of Montgomery cattle, the premier milk breed of India, is maintained. A record of the milk yield of each cow is kept. It is hoped to raise the milking standard (which is now very high) by selection on the basis of these records, and to breed these cattle of one colour and of one type. I draw attention to an interesting illustrated note which will appear in the October number of the *Agricultural Journal of India* for 1909. It refers to a large and remunerative export trade in Indian cattle which has recently arisen. Probably no Indian breed will meet the requirements of this foreign demand better than Montgomery cattle. They are useful for milk, for work and for beef, and in South Africa, in the Southern States of America and in the Straits Settlements they must prove useful, because pure and half-bred Indian cattle have been found to thrive well in these parts and are not affected by flies and ticks in the same disastrous way as local cattle.

Last cold weather 80 Bikanir ewes were purchased. These are a white-fleeced breed with a high reputation for yield and quality of wool. They are being crossed by *dumba* rams to give them hardiness and obtain improvement in the crosses as mutton and wool sheep.

Poultry breeding is now conducted on a fairly large scale. During the last year 19 breeding pens of fowls representing 10 pure breeds and 3 crosses, have been maintained including turkeys, geese and ducks. The experience so far gained indicates that the breed of fowl fully suited to India will have to be developed by crossing.

With this aim in view various experiments are being tried at Pusa. Many enquiries are received for pure bred birds and for eggs for hatching. The farms in several provinces have been supplied with birds, and large orders are being booked from private individuals, chiefly in Madras and Burma. Some of the pure and cross breeds reared at Pusa are being tried experimentally in the hills to determine how they stand the climate.

Botany.—Mr. Howard has done a great deal of useful work for the agriculture and horticulture of India.

He continued to be in charge of his section at Pusa except when he was on leave for six months from August 8th, 1907, to February 8th, 1908, when Mr. R. J. D. Graham, Supernumerary Economic Botanist, carried on the work of the section.

The most important work done by Mr. Howard during the period under report is in relation to wheat. He has nearly completed the botanical survey of the wheats of India. The results are given in the first section of his book, *Monograph on Indian Wheats*, now in the press. Samples of wheat were sent to Mr. Humphries in England for milling and baking tests, the results of which are published in a bulletin. At Pusa several promising wheats have been isolated by selection and are now being tested for yield, agricultural characters and grain qualities.

The plant-breeding work in wheat is now being conducted on a fairly large scale, and the separate cultures, many hundreds in number, extend over several acres. The main objects of this hybridization work are to improve the grain, straw and rust resistance of the Indian wheats. Considerable progress has been made in the investigation into the influence of soil, climate and moisture on the character of the grain in wheat.

Fruit cultivation on an extensive scale has been successfully established. Most of the fruit trees are coming into bearing. The fruit experiments at Pusa have already

yielded results of considerable practical importance. They have proved the suitability of the soil and climate in Behar for growing certain important varieties of fruit.

Preliminary experiments with high class fruit regarding sun-drying, evaporating and refrigerating, have been carried out. A method was devised and successfully tested for sending peaches long distances by rail in India.

During the past year a considerable amount of preliminary work was accomplished by Mr. Howard on oil seeds of the genus *Brassica*, and a general study of the oil seeds of India will be undertaken.

The races of both *Nicotiana rustica* and *Nicotiana tabacum* isolated at Pusa, have been studied. Arrangements have been made with the Peninsular Tobacco Company of Monghyr to conduct experiments at Pusa to ascertain the best varieties and the best means of growing tobacco suitable for the manufacture of cigarettes.

Selection experiments with flax, *Hibiscus canabinus* and *Crotalaria juncea*, were continued, and some promising races isolated.

Three varieties of sisal hemp (*Agave rigida sisalana*) have been established on a small scale.

Progress has been made in the investigation work with barley, *ganja* and opium. The study of the varieties of cassava has been completed, and Mr. Hector is preparing a final report on this subject.

Agricultural Chemistry.—Dr. Leather held charge of this section till 14th April 1909, when he went on leave, and the Supernumerary Agricultural Chemist, Mr. Annett, was appointed to officiate for him. Very few samples of agricultural materials are now sent up by provincial departments for analyses, as these departments have now their own chemists. An appreciable reduction has also taken place in the number of samples received from Native States, the Forest and Irrigation Departments and private persons. Dr. Leather had, therefore, more time for

original research and for larger investigations of importance to Indian agriculture generally.

The work in the pot-culture house has led to important field experiments, the results of which are likely to benefit cultivators at least in Behar in a very substantial way. These field experiments are devised to show that phosphatic manure can with economy and great advantage, be used for certain soils and many crops, particularly in parts of the Gangetic alluvium and especially in Behar.

The Imperial Agricultural Chemist has a very important investigation in progress on the effect of soil or manure on the composition of certain seeds. The results already obtained are remarkable. In conjunction with the Imperial Entomologist, Dr. Leather is investigating the prevention of injury by weevils to wheat and other grains when stored in bulk. This enquiry is of great importance, particularly as it is probable that the American "elevator system" of storing grain may be introduced into India at least on an experimental scale. Mr. Annett has conducted an interesting enquiry into the cause of the dark colour of the black cotton soil. The results of this enquiry are about to be published.

Mycology.—Dr. Butler held charge of this section till 31st March 1909, when the Supernumerary Mycologist, Mr. W. McRae, M.A., B.Sc., was appointed to officiate for him. Mr. McRae arrived in India after deputation for six months to the laboratory of Professor von Tubeuf at Munich. The transfer of the laboratories to the Phipps' building has greatly facilitated the work of this section.

Dr. Butler should be congratulated in regard to the practical application of his work to the ordinary conditions of Indian agriculture.

The requirements of provincial departments still continue to make heavy calls upon the time of the Imperial Mycologist. Collections are being accumulated and worked out with such voluntary assistance as can be got outside

India. Duplicate collections will be as far as possible supplied to provincial departments which already have mycological assistants.

The fungi hitherto recorded from India have been in great part identified, and the information has been made readily accessible.

The research work includes the examination of the life-history and general biology of parasites and their effects on the attacked plants.

The wilt diseases of cotton, indigo, pigeon pea and gram were selected for special study, and the results already obtained will largely help Indian agriculture. A memoir on the work is now in the press. The experiments at the Poona farm to raise a strain of pigeon pea resistant to the wilt disease, have been in progress for four years and are promising well.

Renewed experiments were made to elucidate the methods of infection of the red-rot disease of sugarcane which in India has been for a considerable period a very disastrous disease to this important crop. It is hoped that the new results will be published during the year, and advice of importance given. The study of the life-history of other sugarcane parasites has not yet reached the publication stage.

Dr. Butler inspected the palm disease operations in the Godavari delta in September and December 1907 and in January 1909. Successful inoculations with the parasite were secured during 1908, and a further study of its life-history was made. The campaign against this disease has been particularly successful, and is still being prosecuted earnestly by means of the special staff sanctioned by the Madras Government. I must note the fact that the results of this enquiry by Dr. Butler are so valuable to India that they are equivalent to saving the cost of his section to India for many years to come.

The Imperial Mycologist visited Travancore in September and October 1907 to investigate the cocoanut palm

disease that had broken out in that State. A report on that disease has been published.

The Imperial Mycologist visited Kashmir in 1908 during the months of July, August and September, and enquired into diseases of mulberry and of imported fruit trees. The result of part of this work has been published, and recommendations made for dealing with mulberry diseases. The problem is very important, as many poor people in Kashmir derive much benefit from the silk operations and from the cultivation of good kinds of fruit.

Dr. Butler will complete in a short time the text of a book on Indian plant diseases. It will be of great value to students of agriculture in India.

Entomology.—Mr. Lefroy held charge of this section during the period under report. His indomitable energy appears throughout the work of his section. He continued to direct the work of entomological assistants in the provinces, but their number is still only 13, which is quite inadequate to make an appreciable impression upon the agriculture of India. A beginning only has been made.

The teaching of entomology at the provincial agricultural colleges and also at demonstrations and at shows has made fair progress.

Attention has been given in provinces to the study of the life-histories and habits of injurious insects.

In the Punjab the effects of cotton boll-worm and its parasites has been closely watched.

The work on the insects of the plains of India was continued.

Assistance was given to firms dealing with *mohwa*, with brush-making and with cheroots in regard to insects damaging these articles.

Valuable results have been obtained in the cultivation of *eri*-silk during the past year on a small scale at Pusa, and it is intended to continue this as the basis of a small cottage industry in several parts of India. This industry

is being taken up in Tirhoot and Gujarat. The purely experimental work on *eri*-silk is almost completed. The cultivation of mulberry silk has been taken up.

The question of *tussar* silk is also being investigated.

The cultivation of lac was continued at Pusa as a demonstration to students and for much wider practical application in villages. Some owners of indigo factories in Behar have taken up lac cultivation on a fairly large scale. These men were supplied with seed and information, and their assistants were trained in lac culture. Assistance was also given to the Bikanir State in regard to the possibilities of lac culture there.

Mr. Lefroy has started apiculture with a few stocks of European bees to determine how far they thrive in the plains of India.

The Supernumerary Entomologist, Mr. Mason, visited the various centres at which army stores are baled and stored, to investigate the occurrence in clothing, etc., of the destructive insect *Anthrenus vorax*. On the completion of this enquiry recommendations were made for better baling. Mr. Mason continued the enquiry into the value of insect eating birds.

The general collection of insects of India apart from the purely economic one, has been completely arranged.

Enquiry into the question of preventing the introduction of fungus and insect pests by importation of plants and seeds was made in order to devise remedial measures.

The text-book on *Indian Insect Pests* continues to increase in popularity. Its translation in Bengali has been prepared.

Mr. Lefroy's great work on *Indian Insect Life* has been issued.

A series of excellent coloured plates with short printed explanations illustrating injurious insects, have been issued for use in agricultural colleges, museums and farms and at

exhibitions and shows. This series will be continued and will cover silk, lac, bees and beneficial insects.

The best methods of preparing exhibits of injurious insects for shows are also being tested with a view to find out the class of exhibits that most appeal to the public. Further, a series of lantern slides in colour are being prepared in order that lantern lectures may be given at such shows.

Mr. Howlett, Second Imperial Entomologist, arrived at Pusa in December 1907. He has undertaken the investigation of those biting flies of whose habits little or nothing has been hitherto known in India. With a view to obtain materials for this enquiry, sets of apparatus and copies of the bulletin on biting flies, have been issued to persons and associations likely to render help. In this connection Mr. Howlett is in complete touch with special officers of the medical and veterinary departments. He arranged in February 1909 an exhibition of all kinds of blood-sucking and parasitic insects for the pathological section of the Bombay Medical Congress, and read a paper on the habits of sand flies. He has ascertained the life-histories of nearly all the mosquitos which occur in Pusa, and has found two species of fish which are capable of destroying large numbers of anopheles larvæ. A report on the natural enemies of mosquitos was furnished to the Director of Agriculture, Bengal.

A comprehensive investigation of the several species of fruit flies which attack mangoes, peaches, etc., is in progress. The life-histories of several of these have been worked out, and methods of destroying the mango fly have been tested with success. An attempt to check the annual attack of these pests on the peaches grown at Pusa, was so far successful this year that the period of severity was postponed; thus the Imperial Economic Botanist was able to complete certain experiments.

Mr. Froggatt, Entomologist to the Government of New South Wales, visited Pusa in June 1908, to obtain informa-

tion regarding the fruit flies in India, the Australian fruit flies being related to those found in India. Specimens have, therefore, been supplied to him.

Arrangements have also been made with Professor Silvestri to supply parasites of some of the South Indian species in the hope that they may be utilized against the olive fruit fly, a species which inflicts great damage in Italy.

Specimens have been lent to the Indian Museum, Calcutta, in connection with the revision of nomenclature of various groups of Indian diptera. A large representative collection of tabanidæ has also been lent to the British Museum to assist in like manner the revision of that family now in progress.

Mr. Howlett contributed to *Indian Insect Life* the portions relating to Diptera and the sections on Mallophaga, anoplura and cimicidæ.

A memoir on sand flies is under preparation in collaboration with Dr. Annandale of the Indian Museum.

Mr. Howlett controls the work of the artists at Pusa and is endeavouring to raise the standard of illustration work which is a most valuable part of the publications of the Imperial department.

Cotton.—Cotton continued to receive a great deal of attention from the agricultural departments. Mr. G. A. Gammie who has done much useful work in cotton, was appointed Imperial Cotton Specialist in December 1907. His report is separately published with those of the heads of sections at Pusa. It is unnecessary to minutely review it here. The co-ordination of the experiments that are being conducted on this crop, will now be possible, and Mr. Gammie's advice in the improvement of cotton ought to prove of great help to the department. The principal lines of improvement attempted have been (*a*) selection and distribution of cotton seed, (*b*) introduction of superior indigenous varieties and better methods of cultivation, (*c*) hybridization and (*d*) trial of exotic varieties.

(*a*). SELECTION AND DISTRIBUTION OF SEED.—The distribution of seed of selected pickings from cultivators' fields, has been in progress for more than four years in several provinces, but without any marked result. This is hardly surprising, for such selection, while no doubt supplying sound seed, is, properly speaking, no selection at all, since the fields ordinarily contain many varieties mixed together. It is by separating types and continued plant-to-plant selection that real improvement can be effected. This line of work is now being followed on Government experimental stations with very encouraging results. On the Surat farm, the different types found mixed in Khandesh cotton have been isolated and have been sown separately to determine the comparative value of each. Similar experiments are in progress in Madras. At Akola in the Central Provinces promising work is in progress in the separate cultivation of the four distinct varieties of cotton which are now grown mixed by the *ryots* under the names *jari* and *kati vilayati*. Of these the *malvensis* seems to be a distinctly superior variety, and special attention is being directed towards selection from it.

Eight cotton seed farms were worked by private agencies in the Central Provinces in 1908 under the guarantee of the provincial department against loss. Such farms have been in existence for the last four years. They grow the ordinary *jari* and *bani* varieties of cotton, but are situated in districts which have special reputation for the high quality of their cotton. The seed of first and second pickings is purchased by the provincial department at more than market rates for distribution. In course of time when the selection now going on at the experimental stations has borne fruit, these farms will become useful agencies for the distribution of improved strains of seed. The ultimate object is to establish a number of such farms independent of the department, but receiving, when required, assistance in the provision of seed, trained staff or advice. In the Punjab, Bengal and United Provinces, selection of cotton seed is in progress.

(*b*) INTRODUCTION OF SUPERIOR INDIGENOUS VARIETIES AND BETER METHODS OF CULTIVATION.—There has been a marked extension of this line of work, especially in Bombay and Madras. The introduction of Broach cotton into the Dharwar district has been attended with considerable success. This cotton is superior to the locally grown *Kampta* variety not only in quality, but also apparently in average yield per acre and in lint percentage. In 1908 sixteen thousand pounds seed of Broach cotton from Navsari were sown in these parts in addition to some of the seed of this crop grown locally in 1907. Steps are being taken to get the people to cultivate it properly and to adopt a cleaner system of picking. Some efforts were made to introduce Broach cotton under irrigation in the Deccan, but owing to faulty cultivation and irrigation on the part of the cultivators, the experiments were not successful. Attempts have been made to improve the quality of Broach cotton in northern Gujarat by introducing seed of the superior Navsari variety from the south of the district. In the Tinnevelly district of Madras the *karungani* variety has been found to be superior in quality and yield to the *uppam* variety. Arrangements were, therefore, made by the provincial department to sell pure *karungani* seed sufficient to sow about 8,000 acres in 1908. This work was partly helped by the grant from the British Cotton Growing Association. The Madras Agricultural Department has also made successful efforts to improve the *ryots'* methods of cotton cultivation. Expert cultivators are sent to teach the use of the country drill and bullock-hoe and to demonstrate the value of improved cultivation. Implements are supplied free of cost and expert labourers are sent to help the growers. The advantages of the drill are becoming widely appreciated, and in all 1,000 acres of private land were sown with the drill last year, and many *ryots* have learned to use the drill.

(*c*) HYBRIDIZATION.—Experiments in hybridization were continued at several centres. They have brought to light

some new ideas which, however, require confirmation. The crosses at the Surat farm have been found to be undergoing considerable variation. Although their lints have a relative advantage in quality over the ordinary Surat cotton, the ginning percentage is steadily falling. (The percentage has fallen from 36·9 to 30·3 during the last five years.) The crosses have not yet been grown on a sufficiently large scale to properly test the outturn per acre. The lints of 21 hybrids grown on the Surat station were valued from 5 to 10 per cent. above fine Broach. At Dharwar some encouraging results have been obtained by crossing *inter se* newly introduced varieties from America and Egypt. Work on similar lines is being done in the Central Provinces and Madras, but until the hybrids show greater stability it is impossible to estimate their value.

(*d*) TRIALS OF EXOTIC VARIETIES.—Trials of exotic varieties on Government farms and in cultivators' fields were continued. It is disappointing to have to record a set-back in the expectations previously formed regarding Egyptian cotton in Sind. Up to 1907 the area under this cotton was increasing, but last year, owing to the short supply of water till long after the proper sowing season, the area decreased, and the quantity and quality of the produce much deteriorated. Further, on account of faulty methods of cultivation, careless picking and admixture of leaves and dirt, the produce was so inferior that great difficulty was experienced in disposing of it. There were no bidders at the three auctions held in November, December and January last. The cotton was ultimately sold to a Bombay firm who wanted it for a particular trade purpose and paid only Rs. 9 per maund for *abassi* and Rs. 8-6-0 for *metafifi* as against a minimum of Rs. 11 per maund secured in the previous year.

The average outturn per acre of Egyptian cotton in Sind has been during the last four years much lower than that of the hardier indigenous variety and much less than was originally expected. This is mainly due to bad

cultivation on the part of the *ryots* who do not follow the instructions of the agricultural department. Unless cultivation is improved and sufficient flow irrigation is obtained as early as March-April, there is no likelihood of Egyptian cotton being established as a general field crop in Sind. The Government of Bombay are taking steps to secure these conditions. It is disappointing, however, to record that this year (1909) no sowings in Sind of Egyptian cotton have been made on account of the difficulties of water supply.

Some promising results have been obtained from the trials of American and Cambodia cottons in parts of the Southern Maratha country.

The area sown with American cotton in the Jhelum colony of the Punjab increased in 1907, but on account of the scarcity of labour due to the epidemic of plague, the area was restricted last year. There has been, however, no large decrease in the number of cultivators growing this cotton. Arrangements were made last winter to dispose of the produce by auction as is done with Sind-grown Egyptian cotton, and the results were most satisfactory, the cultivators obtaining an adequate price for their produce. The trials with Egyptian cotton in the Punjab have not yielded any satisfactory results. The Economic Botanist has now imported a new variety which he considers better suited to the Punjab.

Acclimatised American cotton was successfully grown in 1907 by many cultivators in the Aligarh district of the United Provinces, and there was a large increase in the demand for seed for the next year's crop. It is anticipated that the quantity of this cotton will soon be sufficient for putting it on the market on a commercial scale and the prices offered will determine whether it will be permanently established in these provinces.

In the Central Provinces and Bengal *burhi* cotton (an acclimatised variety of American type) has continued to give successful results. Efforts are being made to extend

the area under this cotton and to improve the quality and outturn by selection. In the Central Provinces arrangements were made during 1908-09 to secure a large supply of seed for distribution. It is a good cropper in districts of fairly heavy rainfall, yields a high percentage of lint of good quality and is comparatively immune to wilt.

In Madras and Burma, experiments with Egyptian and other varieties of cotton are in progress.

Tree Cottons.—Further trials with tree cottons have confirmed the opinion which I have previously expressed, *viz.*, that they will never enter into regular cultivation in India. The experiments made by Messrs. Shaw, Wallace and Company with this class of cotton have generally failed. The chief centre of their operations was the Mourbhunj Farm. One hundred and seventy acres were planted out with perennial cottons in 1907. In the succeeding year this area was increased to about 300 acres. In August 1908 the plantations were inspected by me in company with the Director of Agriculture, Bengal, and a report was submitted to Government. The experiments had failed and therefore have been abandoned since March, 1909. Some success has been obtained with the Bourdon variety in the Bombay Presidency and favourable results have been obtained here and there in Assam and Burma, but the place of tree cottons as a field crop in Indian agriculture is very limited.

J. MOLLISON, M.R.A.C.,
Inspector General of Agriculture in India.

SIMLA;
The 5th August 1909.

REPORT OF THE DIRECTOR, AGRICULTURAL RESEARCH INSTITUTE AND COLLEGE, PUSA, FOR THE YEARS 1907-09.

(B. COVENTRY, ESQ.)

1. *Charge.*—The Director returned from nine months' combined privilege leave and furlough on 27th November 1907, and for the remainder of the period under report, was in charge of his office.

2. *Staff.*—The European scientific staff of the Institute consisted as follows :—(1) The Imperial Agriculturist with one Supernumerary, (2) The Imperial Agricultural Chemist with one Supernumerary, (3) The Imperial Economic Botanist with one Supernumerary, (4) The Imperial Entomologist with one Supernumerary, (5) The Second Imperial Entomologist and (6) The Imperial Mycologist with one Supernumerary. Mr. C. J. Bergtheil, Imperial Bacteriologist, who for the last five years was on deputation with the Bengal Government carrying on investigations connected with indigo manufacture, joined his appointment at Pusa on the 1st April 1909, after the expiry of his deputation, but soon after (28th June) relinquished his post. Mr. F. M. Howlett, B.A., Second Imperial Entomologist, arrived from England on the 23rd November 1907 and commenced his investigation on *diptera*. Mr. G. P. Hector, M.A., B.Sc., arrived on the 14th January 1908 and took up the post of Supernumerary Economic Botanist in succession to Mr. R. J. D. Graham, M.A., B.Sc., transferred to the Central Provinces. Mr. W. McRae, M.A., B.Sc., Supernumerary Mycologist, arrived on the 28th March 1908. Mr. W. Roberts, B.Sc., Supernumerary Agriculturist, was deputed to Bombay Presidency in April 1908 to assist the Deputy Director of Agriculture, Mr. A. G. Birt, B.Sc., Supernumerary Agriculturist, was in May 1908 transferred to the Agricultural Department, Eastern Bengal and Assam, as Acting Assistant

Director of Agriculture. Mr. E. Holmes-Smith, B.Sc., Economic Botanist-designate of Burma, arrived from England on the 7th October 1908 to undergo training under the Imperial Economic Botanist, and Mr. G. C. Sherrard, B.A., Supernumerary Agriculturist, arrived from England on the 19th November 1908. Drs. J. W. Leather and E. J. Butler proceeded on leave from the 15th and 1st April 1909 respectively, and Mr. H. E. Annett, B.Sc., Supernumerary Agricultural Chemist, and Mr. W. McRae, Supernumerary Mycologist, were appointed to officiate in the posts of Imperial Agricultural Chemist and Imperial Mycologist respectively.

3. *Scientific Work.*—The scientific work of the Institute during the period is indicated in the reports of the various sections.

4. *College, Grounds, Roads, etc.*—The College building has been taken over from the Public Works Department and has been fully occupied by the various sections. The spacious compound surrounding the College has been laid out; a general improvement in the condition of the roads and avenues has been introduced. Nearly 150 acres have been added to the cultivated area.

5. *Students.*—The College was opened for students in July 1908. The number of students admitted during the year was 19. Of these, 2 came for training in practical agriculture, 2 in economic botany (one for a special course in fruit pruning and weathering), 2 in chemistry, 7 in entomology, 3 in mycology and 3 came for a general course in agriculture. Seven students left after completion of training; one left on account of ill-health, and one was recalled to his province before completion. The student from the Central Provinces who came for a training in entomology died before completing his course. In addition to the training in the agricultural sciences above referred to, special classes have been opened to give a short industrial training in subjects such as lac cultivation and sericulture, and there are now 2 students

receiving a course of instruction in the latter subject. In the coming year it is intended to enlarge these special industrial trainings by the addition of more subjects such as fruit-growing, poultry-management, dairying, etc. It is hoped that these short courses will assist in reviving several old industries and promoting new ones which may profitably be worked as cottage industries.

6. *Publications.*—Much assistance has been given by the senior members of the staff in the preparation of publications. Special mention should be made of Dr. Leather who has had charge of the photographic department, of Mr. Maxwell-Lefroy who supervised the passing through the press of all the illustrations connected with publications, until he handed over the work to Mr. Howlett, and of the latter gentleman who, during the last year, has not only been responsible for the preparation and publication of illustrations, but has also assisted much in seeing the printed matter through the press.

7. *Library.*—The library contains over 6,000 volumes. The transfer of the books from the old building to the new, their arrangement and cataloguing have taken up a good deal of thought and time, and I am greatly indebted for the assistance that has been given in these matters by Dr. E. J. Butler, Mr. H. Maxwell-Lefroy and Mr. A. Howard. A new catalogue, revised and corrected up to 31st December 1908, is in the press.

8. *General Health of the Station.*—The general health of the station has been good. There was an outbreak of chicken-pox and acute ophthalmia amongst the menial establishment in April 1908. In March 1909, there were four cases of confluent small-pox among the subordinate staff; all recovered, and by prompt disinfection and isolation further spread of the disease was stopped. In the hospital, relief was given to 5,716 cases of whom 190 were indoor patients. The number of cases treated amongst European officials and their families was 226. The operations performed numbered 171 of which 14 were major.

REPORT OF THE IMPERIAL AGRICUTURIST FOR THE YEARS 1907-09.

(E. SHEARER, M.A., B.Sc.)

1. *Charge and Establishment.*—The Imperial Agriculturist was absent on privilege leave from 10th September to 4th October 1907, and from 2nd July to 30th September 1908, when his duties were carried on by the Director; for the rest of the period under report he was in charge of his section. Mr. A. G. Birt, Supernumerary Agriculturist, worked in the section until 8th June 1908, when he was deputed to Eastern Bengal and Assam to officiate as Assistant Director of Agriculture. Mr. G. C. Sherrard joined the section as Supernumerary Agriculturist on 20th November 1908. There have been no important changes in the subordinate staff. Excellent work has been done by Mr. Judah Hyam, Veterinary Overseer, who has been in charge of the breeding herds, Mr. Gulabbhai Desai and Mr. M. Ikramuddin, Farm Overseers, and Mr. Ziauddin Hyder, fieldman in charge of the poultry.

2. *Training.*—Four men from Eastern Bengal and Assam have completed courses of two years, nine months, six months, and three months, respectively, in practical agriculture. Of these, two are now in charge of experimental farms; one is a fieldman and the other who is a graduate in agriculture of Cornell University, United States of America, is temporarily in charge of the Dacca experimental farm, but is intended for the post of Agricultural Supervisor in his province. Two students sent by the Punjab Agricultural Department for the general course in agriculture, remained under training. Mr. Gore, Manager of the Salvation Army's farm in Gujarat, came for a short practical course last cold weather.

3. *Cropping and Character of the Seasons.*—The general cropping followed the same lines as in previous

years, being chiefly determined by the requirements of the breeding herds. Areas which promise to be suitable for future experimental work, have been treated uniformly with regard to cultivation and cropping, the produce of each acre weighed separately and the lands otherwise kept under close observation. Two blocks of 9 acres each were selected as suitable for the permanent manurial and rotation experiments referred to below.

The rainfall for the year 1907-08 was 32·35 inches (the normal being about 45 inches) and was badly distributed. There was a long break in the rains in July and August, and from the latter part of September till early January there was no rain. Cold weather sowings were made under very dry conditions, but the rains in the latter part of the cold weather were good. Notwithstanding the generally unfavourable conditions, the crops both *kharif* and *rabi* were excellent. The rainfall from the 1st of June 1908 to the 31st of March 1909 (which covers the *kharif* and *rabi* cropping seasons) was 18·23 inches. The monsoon arrived a full month later than usual and was very scanty, but *kharif* crops turned out to be little under the average. *Rabi* sowings, however, were made with very short moisture, and as practically no rain fell till the crops were in ear, the yields were reduced to less than $\frac{1}{4}$th of the normal. The experience of the last two years would seem to fix the minimum rainfall with which good *kharif* and *rabi* crops can be successively grown on the same land, as somewhere between 20 and 30 inches, if moderately well distributed. A considerable proportion of the rainfall is lost by surface drainage in heavy falls, so that the actual crop requirements are comparatively small. But it is only on very fine grained soils, such as the north Behar alluvium, where evaporation can be reduced to a minimum by suitable cultivation, that full advantage can be taken of the actual rain absorbed by the soil, and again suitable cultivation presupposes good cattle and efficient moisture-conserving implements which in this part of India are in the hands of few.

4. *Special Crops under Experiment.*—These included (*a*) sugarcane, (*b*) jute, (*c*) flax, and (*d*) tobacco.

(*a*) SUGARCANE.—Experimental work on sugarcane is at present confined to determining the best varieties and the best conditions as regards cultivation, manuring, planting and irrigation. The results obtained will have only a local application, and it is recognised that the present work must either pave the way for larger investigations on this important crop, or, if local conditions are found to be unsuitable, work on the crop will be abandoned altogether. In the course of the last five years a large number of thick and of thin varieties of cane from all parts of India have been under trial. With regard to the thick varieties it has been found to be impossible, even with liberal manuring, to obtain the heavy crops grown in the best cane tracts, the maximum yield hitherto obtained being 35 tons of stripped canes per acre. The length and thickness of the individual canes are satisfactory, but the stools are deficient in tillering power, and the fact that many, from various causes, succumb altogether during the growing season, is further evidence of rather low vitality. The thin varieties, on the other hand, in most cases tiller extremely well, and with an application of oil cake or farmyard manure equivalent to 100lb of nitrogen per acre, and with one or at most two waterings after planting, can, in a normal season, be depended on to give yields of 30 tons of stripped canes per acre. This, considering the comparatively low expenditure on the crop, is quite a satisfactory return. Various sugar factories have been established in Behar in the last few years, and these deal almost entirely with thin canes. Provided the difficulty is overcome of securing from a moderate distance a sufficient supply of canes to keep the mills going, there appears to be no reason why these should not prove a success.

(*b*) JUTE.—Forty-four varieties of jute were grown on an area of 8 acres in 1907 and gave an average yield of $16\frac{1}{4}$ maunds of fibre per acre, the season being no better than

the average with regard to moisture conditions. At one time there seemed to be a fair prospect of jute being grown in Behar on a large scale, but the difficulty of obtaining sufficient labour at the time of retting, the fall of the abnormally high prices of three years ago to their normal level, and the fact that in a very dry hot season like that of 1908 the crop may be a complete failure, has discouraged further cultivation. The Fibre Expert to the Government of Eastern Bengal and Assam has taken over the collection of varieties for classification and selection, but otherwise the crop is no longer grown at Pusa.

(*c*) FLAX.—The results of the experiments with flax continue to be promising. In the *rabi* season of 1907-08 the yield and the quality of the flax straw were quite good, and there seems to be little reason to doubt that when the requirements of the crop are properly understood, flax will be capable of being successfully grown in Behar.

(*d*) TOBACCO.—Zimmer's Spanish tobacco was grown on an area of 5 acres in the cold weather of 1908-09 for experimental curing in the curing house, but at the critical moment the expert assistance promised could not be obtained. In any case, owing to the unfavourable seasonal conditions, the crop was considerably below the normal both in yield and in quality.

5. *Manurial Experiments on Wheat.*—In the cold weather of 1907-08, calcium cyanamide and calcium nitrate were compared with sodium nitrate, Indian saltpetre, sulphate of ammonia, rape-cake and farm-yard manure as fertilizers for wheat. Owing to an attack of white-ants and the late application of the manures in a rather dry season, the results of the experiment were somewhat inconclusive, but calcium cyanamide and calcium nitrate proved as effective as any of the other manures except rape-cake. The readiness with which the latter manure becomes available as plant food, even under fairly dry conditions, is remarkable.

6. *Green Manuring.*—Green manuring has been very successful, especially in the case of lands newly reclaimed from jungle. By green manuring such lands, they are immediately brought into a condition of high fertility, whereas under ordinary conditions moderate fertility is only obtained after two or three years' cultivation. Sann-hemp is a crop ordinarily employed for ploughing in. It grows rapidly and gives a large bulk for ploughing in about the middle of the monsoon, and becomes sufficiently decomposed before the sowing of the succeeding *rabi* crop to avoid danger of the land drying out from being too loose. The effects of green manuring are very marked in the two following crops and are discernible for two or three crops more.

7. *Permanent Manurial and Rotation Experiments.*—These were laid down last year according to the scheme described in the Proceedings of the Board of Agriculture, held in February 1908. It will be after some years only that the results obtained will have their full value. The *kharif* yields varied, on the whole, very consistently with the doses of manure applied, thus showing that the land selected was sufficiently uniform for the purpose. The *rabi* sown plots were so poor as in most cases to be incapable of being harvested.

8. *Permanent Pasture Experiments.*—Owing to the ever-increasing contraction of grazing areas in India, it is of importance to know the best conditions under which good pastures can be established and maintained. That good pastures can be grown in many parts of India there is little doubt. An area of 80 acres of unmanured pasture at Pusa was found sufficient to supply all the green food required by two hundred head of cows and young cattle for six months in the year while yielding quite a substantial amount in the remaining six months. Consequently, a series of permanent pasture experiments was laid down in the monsoon of 1907 according to the scheme described in the Proceedings of the Board of Agriculture, held in

February 1908, and it is anticipated that interesting and valuable information will be obtained. Already there is a decided change in the character of the herbage in some of the manured plots.

9. *Breeding.*—The Montgomery herd of cows continues to do well. The high milking qualities of this breed are year by year becoming more appreciated, and dealers from distant parts of India now carry off large numbers from the half-yearly fairs at Amritsar. Out of the Pusa herd of 39 cows, 16 have given over 4,000lb each of milk in their last lactation period (under a year in each case), and of these five have given over 5,000lb each, one has given 6,300lb and another just under 6,000lb. When it is remembered that the average yield of milk in some of the best dairying districts in England, is said to be under 5,000lb, and with a considerably lower percentage of butter fat than is found in the milk of the Montgomery breed, it is possible to realise what a valuable asset India has in the latter. At Pusa there is now the nucleus of what promises to be a very fine herd, and the work of raising its milking power by selection based on the milk records, is probably the most important at present in hand in this section.

The local herd of cattle is still maintained on behalf of the Bengal Government. How far it is likely to prove useful is still uncertain. This year there was considerable difficulty in disposing of all the young bulls even at comparatively low prices. This may have been due to the scarcity of fodder in the district. There can be little doubt, however, that if the herd is to be fully successful, it must be transferred to the Bengal Agricultural Department whose officers alone are in close touch with the districts which the herd is intended to benefit.

During last cold weather 80 Bikanir ewes were purchased. These are a white-fleeced breed with a high reputation for yield and quality of wool. The change from the arid conditions of the Bikanir desert to the moist climate and new food of Behar, induced a severe attack of

dysentery, from which 30 died in a short time. The remainder, however, are now doing well. They are being crossed by a *dumba* ram by which means it is hoped to obtain greater hardiness, constitution and earlier maturity. Attention will also be paid to maintaining the quality of the wool by careful selection.

Poultry breeding is now conducted on a fairly large scale. During the last year there have been 19 pens of fowls representing 10 pure breeds and 3 crosses. It is too soon yet to say how the imported fowls will do. The difficulties of disease and pests incident to the introduction of Western live stock of any sort into India, have had to be faced, and they have been formidable. In the light of the experience already gained, arrangements have been made which will obviate some of the difficulties encountered. Again, many of the more recently produced breeds of fowl are partly of Eastern origin, and for this reason and because of the greater vitality which has resulted from their mixed origin, adapt themselves with greater readiness to Indian conditions. The great fecundity of fowls, as compared with larger animals, is another factor in their favour. But, while there will always be a demand on the part of fanciers for pure breeds, there is little doubt that the breed of fowl fully suited to India will have to be built up in India, and with this end in view various crosses are being tried at Pusa.

10. *General Improvement of the Estate.*—Fully 100 acres have been added to the cultivated area. Much still remains to be done in the way of reclamation, but the back of the work has been broken, and as soon as sufficient work-cattle are obtained, this kind of work will soon be brought to a conclusion.

11. *Programme for 1909-10.*—The permanent manurial and rotation and the permanent pasture experiments will be continued. Experimental work on flax will be continued. Work on sugarcane will be continued. Barley, maize, sorghum, cow-pea, rice and castor varieties will be tested.

Breeding work will be further extended. Selection in the Montgomery herd on the basis of milk records will be continued. It is anticipated that the Bengal Agricultural Department will take over the herd of local cattle. Sheep breeding will be continued on the lines indicated in the report. The breeding and distribution of fowls will be continued.

The training of students will be continued. Attention will be paid to the general improvement of the estate.

REPORT OF THE IMPERIAL ECONOMIC BOTANIST FOR THE YEARS 1907-09.

(A. HOWARD, M.A., A.R.C.S., F.L.S.)

Charge of Office.—The Imperial Economic Botanist held charge of this section during the period under review, with the exception of six months from August 8th, 1907, to February 8th, 1908, when he took combined leave on account of illness, and Mr. R. J. D. Graham, M.A., B.Sc., Supernumerary Botanist, was placed in charge of current duties. While on leave he visited the various botanical gardens and experiment stations in Ceylon and spent some time at Peradenia, the head-quarters of the Ceylon Agricultural Department. He is indebted to Dr. Willis, the Director, for special facilities in studying the work and organisation of his department. Some new ideas were obtained which he hopes to make use of in India. Visits were also paid to some of the leading cacao, rubber, and tea estates in the island. Some work on geographical distribution was done at Newara Eliya, a paper on which it is hoped to publish shortly in England.

2. *Teaching and Training.*—The teaching work of the section commenced on October 1st, 1908, with two students from the Central Provinces. One of these was sent for a special course on the principles of fruit growing, the other for a general course of training in economic botany to fit him for the duties of first assistant to the Professor of Botany at the Nagpur Agricultural College. Both these students did excellent work and profited very considerably by their stay at Pusa. Two students from the mycological section attended the course of lectures and practical work on physiology in this section. During the present session two students from the Punjab have joined the section for a general course, and at least two more students

are expected in October next for the special course on the principles of fruit growing.

In addition to the external students, three supernumerary botanists have received training in the period under report. Of these Mr. R. J. D. Graham, M.A., B.Sc., left in February 1908, to take up the post of Economic Botanist in the Central Provinces. Mr. G. P. Hector, M.A., B.Sc., Economic Botanist-designate of Eastern Bengal and Assam, arrived at Pusa on January, 22nd, 1908, and remained under training. Mr. E. Holmes-Smith, B.Sc., Economic Botanist-designate of Burma, joined the section on October 12th, 1908, for six months' training in economic botany. This period has since been extended.

Mr. Abdul Rahman Khan, formerly Manager of the Lyallpur Farm, joined the section as an assistant on October 11th, 1908, and has undergone a special course of training since. He has worked well, has made a good deal of progress and has shown considerable aptitude for the work of plant breeding.

3. *Wheat Investigations.*—Considerable progress has been made with the investigations on Indian wheat. The quality of the wheat produced in India is a question of the greatest importance, both from the point of view of local consumption, and also of the export trade. Little attention, however, seems hitherto to have been paid to this matter. It appeared likely, both from the appearance of the grain and also of the nitrogen percentage, that some of the pure culture wheats at Pusa and Lyallpur were markedly superior in quality to the ordinary soft whites like Muzaffernaggar largely grown for export. Accordingly the co-operation of Mr. A. E. Humphries, a past President of the Incorporated National Association of British and Irish Millers and the highest authority in the Empire on the milling and baking properties of wheats, was secured with regard to the wheats of India. An arrangement was at the same time made with Dr. Leather, Imperial Agricultural Chemist, for the necessary analytical work to be done at Pusa. The first set of samples for

milling and baking tests were sent to England after the wheat harvest of 1908, and Mr. Humphries' report more than bore out the expectation that India can grow high grade wheats. This report was submitted for publication in the form of a bulletin in September last. Although several of the Punjab samples were superior to Muzaffernaggar white, Mr. Humphries considered that one of the Pusa selections, No. 6, was distinctly the best wheat. The publication of the bulletin has attracted a considerable amount of attention, and it was submitted by the Director of the Punjab Agricultural Department for the opinion of the Incorporated National Association of British and Irish Millers. The council of this association unanimously supported Mr. Humphries and Imperial Economic Botanist, and a full account of the proceedings is to be found in the *Miller* of May 3rd last, and was reprinted in the *Indian Trade Journal* of June 3rd, 1909. A second set of 28 samples of wheats was sent to England for testing during the present year.

Intimately associated with the quality of wheat is the question of the influence of such conditions as soil, climate and moisture on the grain characters. It was found in 1908 that the same sample of Muzaffernaggar wheat sown at Lyallpur, Muzaffernaggar and Pusa, gave rise to grain markedly differing in appearance, analysis and milling and baking qualities. In order to investigate this subject further, and also to discover experimentally a scientific basis for a scheme for wheat distribution in the Indo-Gangetic plain, this work has been considerably extended during the past *rabi* season in collaboration with Mr. H. M. Leake, Economic Botanist to the United Provinces. The co-operation of other officers of the agricultural departments was obtained, and experiments were successfully carried out at the following stations:—Pusa, Bankipore, Dumraon, Partabgarh, Cawnpore, Orai, Alighar, Meerut and Lyallpur. Mr. Evans has promised to assist next *rabi* at Hoshangabad. The results of this year's work will be

published as soon as Mr. Humphries' report has been received.

The botanical survey of the wheats of India was completed during the last year, and an account of this work forms the first section of the book, *Monograph on Indian Wheats*, now in the press. The report on the detailed agricultural survey of the wheats of the Punjab was completed during the year, and for this work the thanks of the Local Government were received through the Director of Agriculture, Punjab. A similar survey of the wheats of Bengal was completed during the year, and the results of this work will be published after the next *rabi* harvest. Bengal apparently possesses some wheats new to science.

Perhaps the most important section of the wheat investigations is that concerned with selection and hybridization at Pusa. Several promising wheats have been isolated by selection and are now being tested for yield, agricultural characters and grain qualities. The plant-breeding work is now being conducted on a large scale, and the separate cultures, many hundreds in number, extend over several acres. The main object of this hybridization work is to improve the grain, straw, and rust resistance of the Indian wheats. The results already obtained are of the very greatest promise.

During the progress of the wheat investigations at Lyallpur, a comparison was made between the wheats of the Punjab and those of the United Provinces. The superiority of the former in vigour and straw characters was most marked. Accordingly during the past year a set of the types of Punjab wheat was placed at the disposal of the Economic Botanist, United Provinces, for growth at Cawnpore. The result surpassed expectations. These wheats showed a marked superiority over the other wheats cultivated at this station, and Mr. Leake has arranged to continue the testing of these wheats in the United Provinces. Besides the report on the Punjab wheats and the

bulletin on the milling and baking tests, two publications on this crop have been completed during the year. A memoir on *The Varietal Characters of Indian Wheats* has been published. Three papers on wheat dealing with the results obtained in the harvest of 1909 are in preparation.

4. *Fruit.*—The fruit experiments at Pusa have already yielded results of considerable practical importance, but it was impossible to find time to write during the last year a second report giving an account of these results. It is hoped, however, to take up this work shortly. Good crops of oranges, limes, custard apples, peaches, plums, guavas, and loquats were grown, and the litchis and mangoes are coming into bearing. Preliminary experiments on sun-drying, evaporating and refrigerating, were carried out, and a method was devised and successfully tested for sending peaches long distances by rail in India.

5. *Fibres.*—Selection experiments in the case of flax *patwa* (*Hibiscus cannabinus*) and sunn-hemp (*Crotalaria juncea*) have been continued, and some promising races isolated. Three varieties of sisal-hemp (*Agave rigida sisalana*) have been established on a large scale.

6. *Oil Seeds.*—During the year a considerable amount of preliminary work was accomplished on the cultivated oil seeds of the genus *brassica*, and the study of the oil seeds of India will be considerably developed during future years.

7. *Minor Investigations.*—The study of the cassava varieties has been completed, and Mr. Hector is engaged in the preparation of a final report on this subject. He has completed the botanical examination of the Pusa pasture experiments, and the final report has been submitted. The work on *ganja*, barley and opium has been continued.

8. *Tobacco.*—A good deal of attention has been paid during the year to tobacco. The races of both *Nicotiana rustica* and *Nicotiana tabacum* which have been isolated at Pusa, have been studied. A memoir summing up

the work on the yellow flowered tobaccos of India (*Nicotiana rustica*) has been submitted for publication, and a second memoir dealing with the classification, description and biology of the races of *Nicotiana tabacum*, is in preparation. The method of growing this crop by furrow irrigation, was further tested and improved during the year. Arrangements have been made with the Peninsular Tobacco Company of Monghyr, to conduct a series of experiments at Pusa to ascertain the best variety and the best means of growing tobacco suitable for the manufacture of cigarettes. This work will be conducted in collaboration with one of the experts of the company.

9. *Programme for 1909-10:—*

(*1*) TRAINING.—The teaching work of the section will be continued on the lines laid down in the prospectus of the Institute.

(*2*) PLANT-BREEDING AND PLANT IMPROVEMENT.—The following crops will be studied:—Wheat, tobacco, barley, oil seeds and fibre plants.

(*a*) WHEAT.—The botanical and agricultural survey of the wheats of Bengal will be completed on the lines adopted in the investigations on the Punjab wheats. The production of improved varieties by selection and hybridization, will be continued as well as the investigation of the factors influencing the quality of the grain.

(*b*) TOBACCO.—The botanical survey of the Indian tobaccos will be completed.

(*c*) OIL-SEEDS.—The study of the oil-seeds of India which has been carried on on a small scale during the past year, will be extended on lines similar to those adopted in the investigations on wheat.

(*d*) BARLEY.—The work on this crop will be continued.

(*e*) FIBRES.—The collection and investigation of fibre yielding plants will be continued.

(3) FRUIT EXPERIMENTS.—The permanent experiments on the culture of Indian fruits will be continued on the lines laid down in the first report.

(4) MINOR INVESTIGATIONS.—The economic importance of the male plant in *ganja* cultivation and the problem of the inheritance of sex, will be determined. The study of cassava as a famine food will be continued in collaboration with Imperial Agricultural Chemist.

REPORT OF THE IMPERIAL AGRICULTURAL CHEMIST FOR THE YEARS 1907-09.

(J. W. LEATHER, PH.D., F.I.C., F.C.S., and H. E. ANNETT, B.Sc., M.S.E.A.C.)

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1. The Imperial Agricultural Chemist held charge of this section till April 14th, 1909, when he proceeded on leave, and Mr. H. E. Annett, B.Sc., M.S.E.A.C., Supernumerary Agricultural Chemist, was appointed to officiate for him. Mr. Annett acted as Agricultural Chemist at the Poona Agricultural College from August 13th to November 22nd, 1908.

2. The several subjects which are under investigation may be conveniently referred to as follows :—

3. *Meteorology.*—The usual meteorological records are kept by this section and forwarded monthly to the Imperial Meteorological Department.

4. *Rainfall.*—A self-registering rain gauge was fitted up at Pusa and used during the monsoon of 1907 in order to obtain some information regarding the rainfall per unit of time. This is wanted in connection with the estimates of the amount of rain water which runs off the land during heavy rains. The instrument was one which was fitted up by the Imperial Agricultural Chemist locally, and yielded only approximate data, and a more exact instrument will be necessary; but such data as were obtained show the heaviest falls during the monsoon of 1907 to be under 2″ per hour. The monsoon was, however, a very weak one and included only one really large fall.

5. *Evaporation.*—An evaporimeter has been experimented with in order to determine the amount of water which evaporates from free surfaces of water. The results so far have not been very satisfactory.

6. *Drainage.*—Records from all the four drain gauges were maintained. In the monsoon of 1907, these differed only markedly in the amount of surface drainage which was greater from No. 1 than from the others. Nevertheless the No. 1 gauge probably yields the most reliable data. Nos. 2 and 4 had grass on them and were expected on this account to behave differently from Nos. 1 and 3. The rainfall was sufficiently heavy on two occasions to cause an overflow from the pipe fixed at a nominal 2″ above the ground level, and the amounts that ran off were 0·5″ during a 4″ rainfall and 3·5″ during a 7″ rainfall. The amount of water which percolated was 7·5″. The rainfall was 40·3″ during the year (October 1906 to September 1907), and the amount which evaporated during the twelve months was accordingly 28·8″. These are the quantities measured from No. 1 gauge.

The data of the drain gauges at the Cawnpore farm and the samples of the drainage water from them, are provided for this section by the courtesy of the Director of Land Records and Agriculture, United Provinces. The four years' data obtained from these gauges, show that the evaporation there amounts to between 14″ and 20″ in extreme cases, and that the average is approximately 17″ per annum. Hence the amount lost from the Pusa soil is considerably greater than at Cawnpore. This result is probably fully explained by the fact (referred to below) that the Cawnpore soil contains less maximum water per cubic foot than the Pusa soil.

Regarding the constituents which are dissolved in the drainage water, the total amount of nitrogen (as nitrate) in the drainage water was 20lb per acre from the bare fallow soil and ·04lb from that growing grass. This year maize is being cultivated on gauges Nos. 2 and 4 in place of grass. The Cawnpore gauge soil which is maintained fallow, continues to yield large amounts of nitrate. This varies, however, a good deal with the rainfall and also with the depth of the gause. Over a series of years these gauges are yielding approximately equal

amounts of nitrate, but it is not all washed out during the same season; up to the present the deep gauges yield large amounts in a very wet year, whilst the shallower ones, although yielding also more in a year of heavy rainfall than in one of small precipitation, fall short of the deep gauges in this respect, and then recover their position in a year of short rainfall. The data are, however, meagre, and in any case the subject is closely related to that of the period when nitrates are principally formed and their subsequent disposition in the soil, a subject which, though understood fairly well for European conditions, is far from being so for Indian soils.

The monsoon of 1908 was such a weak one that practically no drainage was recorded from any of the four gauges. The rainfall this year up to June 30th has been considerably above the average. Up till May 31st, 1909, 5·15″ of rain fell. In June 28·96″ fell. Percolation began in gauges Nos. 3 and 4 (the 3′ gauges) on June 10th, after 12·31″ of rain (reckoning only June rainfall) had fallen. In the 6′ gauges, Nos. 1 and 2, percolation began on the 11th and 12th June respectively.

Much trouble is caused by the burrowings of various insects into the gauges, and probably largely from this cause gauge No. 2 (a 6′ gauge) has leaked considerably, and part of the drainage water from this gauge has had to be ignored.

7. *Loss of Water from Soil.*—The data relating to the first year's records of the amount of water in the soil at Pusa during the dry season 1906-07, and the deductions made therefrom, have been published as a memoir, No. 6, chemical series. The views put forward in that memoir have been supported by further experiments in the field, the results of which are about to be published.

In order to gain experience of other soils, similar records have been kept at the Cawnpore Agricultural Station, and through the courtesy of Mr. C. Rudston Brown, at Bhatowlia Indigo Factory in Behar, in addition

to another series at Pusa, determinations of the amount of water present in the soil having been made monthly throughout the dry season 1907-08. The latter season was unusually dry at Pusa, so that the soil here was desiccated to a greater extent than generally happens. After reviewing the data of the two seasons, it was found that too much weight had been placed on the effect of atmospheric humidity in the first method of calculating the rate of loss, and that the latter can be accounted for by the effect of temperature in addition to the special characteristics of the soil. The calculated values agree very closely with those found. The data for the Cawnpore soil show it to possess a marked difference from the Pusa soil in the amount of water present at the conclusion of the monsoon, for this quantity is only about 16lb per cubic foot, whereas the Pusa soil contains about 25lb. Moreover, during the season it lost water only to a depth of three feet as against seven feet at Pusa.

The soil at Bhatowlia was selected, because it is a coarse sand for more than 10 feet. This soil only contained about 5lb water per cubic foot at the conclusion of the monsoon.

8. *Water Required by Plants.*—An investigation of the amount of water transpired by plants, was commenced in 1907 by the pot-culture method. In the following cold weather one field experiment was made in conjunction with the latter, and it was found to yield data in close correspondence with those obtained from the pot-cultures. During the last year the pot-culture investigation was extended so as to include (*a*) a larger variety of crops and (*b*) a number of essentially different soils, and in conjunction with this a series of field experiments with various crops was carried out. The data which have been obtained have been put together in a memoir which will shortly be published under the title of "The Water Requirements of Crops in India."

9. *Available Plant Food in Soils.*—This investigation continues to occupy a part of the time of the section, but

is much more complicated than some of the other works. The phosphates form the chief objective, because of the importance which the more perfect valuation of this group of constituents in soils would possess. The only area in which field experiments have been made up to the present in conjunction with the laboratory work, is in Behar. The soil of a large part of Behar is, so far as one can tell from laboratory tests, greatly deficient in readily assimilable phosphates, and field trials were made during the monsoon of 1907 and the following cold weather. The former yielded doubtful results, but the latter yielded, with one exception, considerable increases due to superphosphate.

10. *Soil Gases.*—Closely allied to the study of the assimilable plant food in soils, is probably a more perfect knowledge of the nature of the gases in soils and their quantity. Such information as we possess regarding this subject is but meagre, and since the Indo-Gangetic alluvium offers an exceptionally suitable material for the work, an investigation in this subject was commenced. The results obtained have been embodied in a memoir entitled "The System Water, Calcium Carbonate, Carbonic Acid."

11. *Black Cotton Soil.*—An investigation into the nature of constituent or constituents of this soil which occasion its peculiar colour, was undertaken by Mr. Annett, Supernumerary Chemist. The results obtained from this investigation are about to be published.

12. *Other Investigations.*—Chief among these is a determination of how the composition of the various crops grown on the permanent experiment plots at Pusa, varies with different systems of manuring.

In conjunction with the Imperial Entomologist, some work has been done with the object of freeing stored wheat grain from weevil.

13. *General Analytical Work.*—The number of samples of agricultural materials which are sent by the provincial departments for general analysis, is now practically *nil*. The chief calls on the laboratory for this purpose

are made by Native States, the Irrigation Department and private persons. The number of such specimens examined is about $\frac{1}{5}$th of what it formerly was. This section of the work is now nominal and does not seriously interfere with other work.

14. *Students.*—Three students, two from the Punjab and one from Eastern Bengal and Assam, attended for a course in general chemistry from October 1908 till March 1909. These were all students taking the general course in agriculture. In June 1909, one student came to be trained as Analytical Assistant to the Agricultural Chemist of Bengal.

15. *Establishment.*—Mr. J. N. Sen, M.A., senior laboratory assistant, was, on the opening of the College in July 1908, appointed teaching assistant. Mr. D. B. Darab Sett, B.Sc., resigned his appointment to take up the post of Senior Assistant to the Agricultural Chemist, Burma. Mr. S. C. Kar took his M.A. degree at Calcutta University. Mr. D. N. Chatterjee, B.A., B.Sc., and Mr. C. S. Rama Aiyer, B.A., were appointed Junior Assistants. All the establishment have worked well and given great satisfaction.

16. *Programme for 1909-10.*—The programme of work for the coming year is chiefly a continuation of that described in the foregoing report which may be briefly summarised as follows :—

(*1*) Maintenance of drainage records.
(*2*) Determination of the rate at which water is lost by soils.
(*3*) Ascertainment of the water requirements of plants.
(*4*) Investigation of the work on the availability of plant food in soils.
(*5*) Investigation of the nature of the dark colour of black cotton soil.

The investigation of nitrification in Indian soils will be taken up if possible.

The effect of soil or manure on the composition of certain seeds is an investigation which has been in progress tentatively and will be extended if considered desirable.

The prevention of weevil attacks on wheat is an investigation which is being conducted in collaboration with the Imperial Entomologist.

Instruction will be given to students on the lines indicated in the Pusa syllabus.

REPORT OF THE IMPERIAL ENTOMOLOGIST FOR THE YEARS 1907-09.

(H. MAXWELL-LEFROY, M.A., F.E.S., F.Z.S.)

Training.—Students from the agricultural departments of the Punjab, Baroda, Bombay and Eastern Bengal and Assam were fully trained during 1907-09. As this is the first year, the full course of training was given under proper conditions. A considerable proportion of time was given to it, and the lecturing from October 1908 to April 1909 done by the Imperial Entomologist. The organisation and carrying out of this course has been the most important work of the last two years, and it is to be regretted that so few students took advantage of it. A short training, as part of the course in general agriculture, was given to two students from the Punjab and to a fieldman of the Fibre Expert, Eastern Bengal and Assam. Students from the United Provinces, Madras and Bengal arrived in June 1909.

2. *Establishment.*—The assistant for sericulture, Mr. L. M. Dass, was recently appointed; there have been no important changes. The First Assistant, Mr. C. S. Misra, has had direct charge of students, of the field work on the Pusa farm and the work with lac. Apart from the courses of lecturing given personally by the Imperial Entomologist, Mr. Misra has had charge of the practical and field work of students, which he has done in an admirable manner. He also visited Sind in reference to the boll-worm on cotton. The Second Assistant, Mr. C. C. Ghosh, has had charge of the insectary and has had very heavy additional work in connection with *eri*-silk, of which he will now be relieved. His work has been of great value. The Third Assistant, Mr. G. R. Dutt, has been in charge of economic records and collections, and has done

original work on aculeate hymenoptera. The assistant in charge of the collections, Mr. D. Nowrojee, has done excellent work with the arrangement and upkeep of the general insect collections which are now permanently stored in a proper manner. The Bengal assistant worked in the laboratory, as there is no proper accommodation for him as yet at Sabour, and with the Second Assistant, Mr. C. C. Ghosh, prepared the revision in Bengali of *Indian Insect Pests*, in addition to his ordinary work. The staff of the Second Imperial Entomologist worked under the guidance of the Imperial Entomologist until the arrival of this officer, and the artist's staff of the Institute also worked under him till March 1908.

3. *Buildings.*—The section moved into the permanent laboratory during May 1908. The section is now established in permanent quarters in the laboratory; the insectary, silkworm house and a godown are also being occupied.

4. *Provincial Work.*—The number of assistants employed in entomological work in the provincial agricultural departments is now 13, for teaching, demonstrating and field work. This number is inadequate to bring the practical work of entomology effectively before the agricultural classes, but a beginning is being made with practical teaching of entomology at the provincial agricultural colleges and also with demonstrations at shows. In March last, a meeting of the assistants was held at Pusa to discuss progress, to demonstrate improvements, to show the work in silk and lac, to teach how to put up show-cases for exhibitions and to arrange how best effective assistance could be given from Pusa, especially with regard to shows and demonstrations. The work of provincial assistants is under general direction from Pusa, in the sense that their monthly reports and programmes are sent here for criticism; assistance is given in preparing their programmes in all technical matters such as identifications, supply of apparatus, books, etc., and in the teaching given

at the college. There is no uniform system for all provinces, and the relations are closer in some cases than others, but all assistants can obtain the effective assistance of this section, where it can be given. Progress has been made in the general study of injurious insects in the provinces, notably in Madras, where a careful study has been made of the *surul* pest of groundnut, of paddy stem-borers and of the general pests of the province. In Bombay, an enquiry was made into the occurrence of the potato moth. In the Central Provinces, Bengal, Eastern Bengal and Assam and the Punjab, the general investigation of injurious insects has been continued, and in the last named province the progress of cotton boll-worm and its parasites has been closely watched. A general strengthening of the staff is required in most provinces.

5. *Correspondence.*—As in previous years, there has been a large volume of enquiries on all matters connected with insects; the enquiries directly connected with insects injurious to crops, have been in part diverted to provincial departments, but a large mass of miscellaneous enquiries has been received and dealt with. Excluding correspondence with provincial agricultural departments, these are received from commercial firms, planters and planters' associations, zemindars, fruit-growers, superintendents of experimental farms and botanical gardens; specimens sent for report by the members of the Bombay Natural History Society, are, in some cases, forwarded and dealt with here, and there is a certain number of enquiries from persons interested in entomology for the identification of specimens. The increasing interest in silk, lac and bee-keeping also produced a large number of enquiries. Over one thousand of such enquiries were dealt with by the Imperial Entomologist personally during the last two years, and this work is, by no means, the least useful part of this section's activities.

6. *Research.*—Progress is steadily made with enquiry into the life-histories and habits of injurious insects. The

more important have been the cotton boll-worm, the potato moth, two cockchafer beetles, the mango leaf hopper, the *mohwa* beetle, the *singhara* beetle, the bristle beetle, the surface grass-hoppers, the big cricket, the rice and cane hispas, the sweet potato weevil, the *til* hawk moth, the Behar hairy caterpillar, the *tur* pod bug, the cane leaf hopper, the armyworm of rice, the rice stem-borer, the melon weevil, the rice and cane mealy bugs, the rice leaf hopper and the pests of castor, rice and indigo. The influence of climatic changes upon insect life and the problem of utilizing beneficial insects, have also been investigated. The search for an insecticide less poisonous than arsenic was continued and brought to a conclusion, the field trials showing that the new insecticide is extremely effective. An enquiry into the best method of checking thrips on tea in Darjeeling was taken up by arrangement with the Scientific Officer of the Indian Tea Association and spraying trials made; the method tried was found satisfactory and is in use at present. In connection with potato moth, the trial of methods of seed potato storage was made, and this work is being carried on in collaboration with the Central Provinces Agricultural Department. Trials are being made in the Central Provinces and also in Bengal. The relation of the wheat weevil to the percentage humidity of wheat is being investigated in collaboration with the Imperial Agricultural Chemist, for the Department of Commerce and Industry. Cantharides or blister beetles are a pest in India, and an endeavour is being made to ascertain if they are of commercial value, so that those who suffer from them, may derive profit from collecting them. The enquiry into the food of birds was continued by Mr. Mason, as also investigation of methods of fumigating plants, grain, etc. The question of taking steps to check the promiscuous introduction of noxious insects from other countries, was under consideration, and recommendations were made for dealing with plant imports. Mr. Mason visited the centres at which the army stores are baled and stored to investigate the occurrence in clothing, etc., of the

destructive insect *Anthrenus vorax;* this enquiry was completed and recommendations made for better baling. The question of apiculture was taken up to determine how far bees will thrive in the plains, and whether apiculture can be carried on sufficiently well here to enable it to be a subject for demonstration and teaching; this work is in progress.

7. *Sericulture.*—The cultivation of *eri*-silk was continued, and the process of spinning, dyeing and weaving taken up. This is carried on as a demonstration to students of the value of this silk as a home industry in India, and to enable any one who wishes to start it, to be taught the work practically. A practical spinning machine of a simple kind was devised by Mr. Ghosh which is now in use; it is being improved, and its value is being thoroughly tested. During the meeting of the assistants in March last, the work was taught to them, so that they could, if opportunity arose, give advice. The Superintendent of Sericulture of the Baroda Government also came, as this silk has been introduced in Gujarat. The publication of an article in the *Agricultural Journal of India*, the exhibition at the Muzafferpur show and the work of the Baroda Agricultural Department, have drawn attention to the possibilities of this silk; it is being taken up in Tirhoot, Gujarat and elsewhere, and enquiries about it have been received from every province; eggs have been supplied free, or at a small price, to all who have asked for them, and the work has been shown to many enquirers. It is probable that this silk will be taken up in many parts of India, and that an industry will spring up, similar to that existing in Assam, which will give light remunerative work to women and children. Arrangements were made to supply cocoons for spinning as a famine relief work for *purdah* women in one district, and the work is being organised in some Tirhoot indigo concerns. It may be noted that the staff for this work consists of one assistant newly appointed, a fieldman and the coolies actually doing the work in

the silkworm house; to properly develop this industry would require a staff available for temporary service in tracts where conditions are favourable; the only men available for demonstrating in outside places are trained coolies, and there is room here for an increase of staff; so far as possible, requests for assistance are met from the available staff. As the purely experimental work on *eri*-silk is almost completed, the cultivation of mulberry silk has been taken up; the main object is to determine how far it is possible to grow mulberry silk profitably, to supply the raw material which is imported at present and to supplement the supply of raw silk produced at present in Lower Bengal, to see whether improvements can be effected and to provide instruction in rearing and reeling if the prospects are favourable.

The question of *tussar* silk is also being investigated, besause in this, as in other silks, advice is asked on points which can be determined only by entomological, as apart from purely sericultural, enquiry.

8. *Lac.*—The cultivation of lac insect on *ber* (*Zizyphus jujuba*) has been continued, and progress made in extending the cultivation in Tirhoot. Seed has been supplied, and men trained for twelve indigo concerns in Tirhoot, and advice given about the cultivation of lac to many enquirer. Lac inoculation was done for the Public Works Department of Bengal in connection with canals, and assistance given to the Bikanir State in regard to the possibilities of lac culture there. The cultivation of lac as an adjunct to ordinary cultivation has been explained in an article for the *Agricultural Journal of India*, volume IV, part 3, and it is solely from that aspect that it is being done. The work of assisting the cultivation of lac will probably expand. Training in lac cultivation is given at Pusa at the present time, and advice given to enquirers.

9. *Insect Survey.*—The general collection of insects of India, apart from the purely economic one, has been transferred to its permanent quarters and is completely

arranged and catalogued. Mr. C. W. Mason has arranged the Lepidoptera, the Assistant to the Second Imperial Entomologist the Coleoptera. A large part has been sent to England for the use of authors of prospective volumes of the fauna of India; the Orthoptera, Neuroptera, Braconidæ and Ichneumonidæ, Cetoniidæ Chrysomelidæ, Curculionidæ, Microlepidoptera and Rhynchota Homoptera are the larger collections being worked at in this way. A large part has been returned, and the whole collection is yearly becoming more complete and useful. The greatest help was given by the late Colonel Bingham, and by his death we have lost an able collaborator who gave invaluable assistance to all who are interested in Indian entomology. We have now a good reference collection as well as a separate collection for students, of the insects of Pusa, both of which are necessities in daily work. In conjunction with the Indian Museum, the results of the past work are being worked up and utilised in determining the zones of insect life in India. Specimens were exchanged with the Indian Museum; a collection of Coleoptera was identified for the Bombay Natural History Society and completed from our duplicates. Similar collections were identified and made up for provincial agricultural colleges, and their collections are sent here for identification and arrangement. A good collection is the basis of accurate work and teaching, so that this work is of importance and can be done from Pusa only. The formation of the collection will be continued, but less time will be devoted to it.

10. *Demonstration.*—A series of excellent coloured plates with short printed explanations, has been issued, which are used for teaching in colleges, are exhibited at demonstration farms and are made up into show-cases for exhibitions and shows. This series will be continued and is being expanded also to cover silk, lac, bees and beneficial insects. As the work of the provincial departments expands, this work will also expand; and, since only simple methods of checking pests can be used, the teaching of the people and the demonstration of simple facts and remedies

will become an important part of the work. In all provinces, teaching at colleges, enquiry into local pests and demonstrations both of facts about insect life and remedies for pests, are now going on.

In February last an exhibit of injurious insects, lac and *eri*-silk was sent to the Muzafferpur agri-horticultural show. Increasing attention is being paid to this in provincial departments and the best methods of preparing such exhibits are being tested here; a complete exhibit in show-cases has been prepared as a model, and it is proposed to send exhibits to shows or to assist in this work to gain experience as to the class of exhibits that most appeal to the public. Show-cases of injurious insects, silk, lac, etc., with specimens, plates and explanations in the necessary languages, have been prepared for some provinces and will be prepared by the entomological assistants in others; and, as an aid to these, series of lantern slides in colour are being prepared in order that lantern lectures may be given at such shows. This work will be an additional tax on the time both of this section and of the provincial assistants, but it falls chiefly at one season and is an extremely important work.

11. *Publications.*—The marked influence of *Indian Insect Pests* is noticeable, and its publication in 1906 has been abundantly justified. A simplified revision in Bengali has been prepared and proposals submitted for its publication. Other vernacular revisions will follow as provincial work expands sufficiently to make them possible.

A text book on "Indian Insect Life" has been issued in July last. The issue of this volume of over 800 pages with over 500 half-tone illustrations and 85 coloured plates has entailed very heavy work which has fallen entirely upon the Imperial Entomologist. The publication of the volume completes the preparations for proper teaching and marks the close of the period of preparation of the past six years. The series of memoirs on injurious insects were continued, and popular articles on those of great importance

written for the *Agricultural Journal of India*. The influence of the latter is shown by the immediate increase in correspondence from the public in India after the publication of an article on a particular subject.

12. *Conclusion.*—As this is the only entomological centre in India, the section is so fully occupied in the immediately practical work of answering enquiries, assisting provincial departments, facilitating the teaching of agricultural entomology and assisting in the establishment of insect industries, that there is no time to apply research to subjects not of immediate necessity and this must be so until the staffs of the provincial departments expand. Research, as ordinarily understood, is done here only so far as will enable a practical answer to be given in each definite practical case. The progress that has been made in all branches of the subject and its great practical importance justify an expansion of the staff both at Pusa and in the provinces. To practically apply the results gained and to continue the progress which has been made possible from the research and enquiry of the past, require a constant expansion especially in provincial departments setting Pusa free to continue the work of enquiry.

13. *Programme for 1909-10.*—The work of the past in studying and advising on crop pests will be continued. Assistance will be given, when desired, in directing the work of provincial assistants, in coping with outbreaks of crop pests and in organising exhibitions for agricultural and other shows. The issue of coloured plates will be continued. Enquiries in progress on potato moth, fumigation of plant imports and grain and on wheat weevil will be continued. Advanced teaching in entomology will be continued. The question of publishing vernacular translations of the revised text of *Indian Insect Pests* will be considered. The possibilities of apiculture in the plains will be tested at Pusa. A short practical course of instruction in *eri*-silk and in lac culture will be given if required. Mulberry silk culture will be continued with a view to

offering instruction in rearing and simple methods of reeling. If possible, the question of producing better races will be taken up experimentally, but this may not be possible if the practical courses of teaching occupy much time.

REPORT OF THE SECOND IMPERIAL ENTOMOLOGIST FOR THE YEARS 1907-09.

(F. M. HOWLETT, B.A., F.E.S.)

1. *Charge and Establishment.*—Mr. Howlett arrived at Pusa in December 1907, and has been in charge of the section since. The staff consists of Mr. D. Nowrojee, First Assistant, with Messrs. P. G. Patel and H. N. Sharma, special Fly Assistants. Of these, Mr. Nowrojee carries on his previous work on Coleoptera, and Mr. Muhabat Singh has been detailed in his stead for work on the flies affecting crops and fruit. Mr. P. G. Patel has made a number of original observations on ticks, sand flies and muscidæ, and has had charge of the general collection; Mr. H. N. Sharma has been occupied with the life-histories of mosquitos and investigation of their natural enemies. All have done good work in their particular branches.

2. *Training.*—Since diptera constitute a special group of insects requiring special methods and careful manipulation, a considerable amount of attention has been given to the instruction of the staff in these methods. Mr. P. G. Patel was sent to Belgachia, at the request of the Civil Veterinary Department, Bengal, to give a course of instruction relating to biting flies injurious to cattle. Messrs. P. N. Das and Syed Mohomed Raza Husain, of the civil veterinary departments of Bengal and the United Provinces, respectively, came to Pusa for a course of training in methods of observing and collecting pests and parasites of cattle and other stock. As a part of the course given to agricultural students in entomology, lectures were given on diptera and on blood-sucking insects, special attention being paid to fruit flies and cattle parasites. A short series of lectures on more purely economic lines was given to the provincial entomological assistants

on the occasion of their last visit to Pusa. Mr. Chimaswami Pillai, sent by the Madras Government for instruction in methods of illustrating, finished his course and returned to Madras.

3. *Work on Publications.*—That portion of the book, "Indian Insect Life," which relates to diptera and the sections on mallophaga, anoplura and cimicidæ, was completed, and the necessary illustrations prepared by the Second Imperial Entomologist or under his supervision, as were also a large number of the illustrations for the body of the work and other illustrations and maps required for memoirs and for the *Agricultural Journal of India.*

The business of seeing the *Agricultural Journal of India* through the press, and all work connected with the reproduction, etc., of the illustrations in zinco, half-tone, lithography and the three colour process, was also undertaken.

In February last the Second Imperial Entomologist acted as Secretary to the Board of Agriculture at the Nagpur meeting and prepared for publication the proceedings of the meeting.

The supervision and direction of the artists' staff of the Institute have been undertaken, and besides the work done for the various sections at Pusa, assistance has been given to the civil veterinary departments and to the Bombay Natural History Society in preparation of special illustrations of blood-sucking flies and of living snakes.

4. *Entomological Work.*—Work was done on the rice, *tur* pod and pea-stem flies. The first named was found to be doing serious damage to wheat (planted after rice) in Sibi, Baluchistan, and Mr. Muhabat Singh was sent to investigate and report on the outbreak. Work was done in fruit flies, and an attempt to check the annual attack of these pests on the peaches grown at Pusa, was this year so far successful that the period of severity was postponed until the Imperial Economic Botanist was enabled to complete the experiments in progress. It is unlikely that

any method short of netting, will have any radical effect on the flies under the conditions at Pusa. Methods for destroying the mango fly (the most destructive species in Behar) have been tested with success. Mr. Froggatt, Entomologist to the Government of New South Wales, visited Pusa in June 1908 for the purpose of obtaining information on the subject of fruit flies, as the Australian fruit flies are related to those found in India and constitute a very serious obstacle to the successful cultivation of fruit there. Since his return he has been supplied with fruit flies specimens for the purpose of assisting his investigation on the Australian species. Arrangements have been made with Professor Silvestri to supply parasites of some of the south Indian species in the hope that they may be utilised against the olive fruit fly, a species which inflicts great damage in Italy.

Among blood-sucking flies attention has been directed chiefly to the life-histories of sand flies, tabanidæ and muscidæ, and the Pusa species are now fairly well-known. A number of specimens have been received from various parts of India, from the officers of the civil veterinary departments and from medical men. A report on 800 specimens received from Bengal was communicated to Mr. D. Quinlan, Superintendent, Civil Veterinary Department, Bengal, and data as to the distribution of the various species are thus being obtained.

A number of specimens have been identified for medical men and for private individuals, and various enquiries regarding blood-suckers, parasites, infective and predaceous insects, have been received and answered. A report on the value of certain insecticides advertised as being efficacious against various parasites, has been supplied to the Inspector-General of Agriculture in India. Arrangements are in progress for supplying Indian blood-suckers to the Sleeping Sickness Commission in Uganda for the purpose of testing the possibility of sleeping sickness being transmitted by any Indian species as well as by the tsetse fly.

The life-histories of nearly all the mosquitos which occur in Pusa have now been ascertained, and a special study has been made to discover any efficient natural checks on their increase. Two species of fish have been found to be capable of destroying large numbers of anopheles larvæ, while a small water insect seems not unlikely to prove a useful check on culex; experiments on a large scale have not yet been tried.

Observations on the life-history and habits of ticks have been made, and experiments on the best means of destroying them.

Some attempts have been made to discover the effect of various physical conditions on mosquitos and other blood-sucking insects, but, though some minor results of interest have been obtained, this very important line of research demands more time than the Second Imperial Entomologist has been able to give.

A considerable number of specimens have been lent to the Indian Museum in order to assist in the revision of the nomenclature of various groups of Indian diptera, and a large representative collection of tabanidæ has been lent to the British Museum to assist in like manner the revision of the family now in progress.

In January last a number of specimens, drawings and photographs of various blood-sucking species, were contributed to an exhibition of disease-carrying insects organised by Dr. Annandale at the Indian Museum.

In February last an exhibition of all kinds of blood-sucking and parasitic insects was arranged for the pathological section of the Bombay Medical Congress; a few slides and specimens were lent for incorporation with other exhibits; a simplified key to the different kinds of blood-sucking insects, was written for the use of visitors to the exhibition; a paper on the habit of sand flies was read before the pathological section; and a public lecture on blood-sucking insects delivered. The Second Imperial Entomologist derived much pleasure and benefit from the

opportunity of meeting and conversing with medical men from all parts of India.

5. *Correspondence.*—A considerable amount of correspondence has been involved in the investigation on biting flies. Sets of apparatus and copies of the bulletin on biting flies have been issued to the Directors of Agriculture, Punjab and Bengal, the Assistant to the Chief Commissioner, Baluchistan, the Assistant Political Agent, Khelat, the Honourable the Agent to the Governor-General, Quetta, His Britannic Majesty's Consul, Seistan, the Honorary Secretary, Baluchistan Natural History Society, the superintendents, civil veterinary departments, Bengal and Eastern Bengal and Assam, the officer investigating camel diseases, the officers of the Indian Medical Service and Royal Army Medical Corps, and private individuals in all parts of India, and it is anticipated that the material thus obtained will greatly assist the enquiry.

Correspondence on matters connected with the working out and identification of the collections, has been carried on with experts in Europe and America and on various scientific subjects with the bacteriological laboratory at Parel, the Indian Museum, the Bombay Natural History Society, etc., and with various private individuals.

6. *Conclusion.*—The necessity of devoting a considerable amount of time to the illustrating and publication work of the Institute naturally restricts, to some degree, the work connected with pure entomology. During the past year the illustrating work had at times been particularly heavy. A further restriction is due to the fact that no laboratory accommodation was originally provided for this section, with the result that all work has to be carried on in a single room which perforce serves the purposes of office, laboratory, store-room, collecting room and insectary. The very important work on life-histories of insects in particular has suffered for lack of a suitable place for carrying on breeding operations, and there is no accommodation whatever for students.

The number of enquiries received is considerable and is expanding, but without further accommodation it will be impossible to cope with the expansion.

7. *Programme for 1909-10.*—Work on blood-sucking insects and parasites injurious to cattle and poultry will continue, and arrangements have been made for an investigation, in collaboration with Mr. Leese, Veterinary Officer investigating camel diseases, Lahore, on insects capable of transmitting *surra*.

Trials will be made of the relative value as checks of the various natural enemies of mosquitos discovered at Pusa, and to ascertain whether the introduction of Indian fish is likely to prove of practical value in eradicating *anopheles* in places where other measures are impracticable or difficult.

A short course of lectures on pests of live-stock and poultry for agricultural students, is being drawn up in collaboration with the Imperial Agriculturist, and all necessary assistance will be given in carrying out the ordinary course for students at Pusa.

Attention will chiefly be directed to the dipterous pests of crops and fruit and to the study of the tachinid parasites of insects found at Pusa. The collection of diptera will be as far as possible worked out from the systematic point of view.

The publication work and the control and supervision of the artist's staff will continue as hitherto, unless other arrangements are made for the allotment of the duties in connection with this branch.

REPORT OF THE IMPERIAL MYCOLOGIST FOR THE YEARS 1907-09.

(E. J. BUTLER, M.B., F.L.S., and W. McRAE,, M.A., B.Sc.)

1. *Charge and Establishment.*—The Imperial Mycologist held charge of his section till the 31st March 1909, when he proceeded on combined leave, and Mr. W. McRae, who had joined his appointment as Supernumerary Mycologist in March 1908, after a period of six months on deputation in the laboratory of Professor von Tubeuf at Munich, was appointed to officiate in his absence. The first assistant, Mr. S. K. Basu, resigned his appointment with effect from 16th December 1908. The post is not yet filled up. The appointment on probation of Mr. T. S. Lakshman Rao as assistant to the Supernumerary Mycologist, terminated on 31st March 1909, when Mr. A. Hafiz Khan, second fieldman, was promoted to the post. L. S. Subramanium, clerk on probation, was appointed third fieldman.

2. *Laboratory.*—The section moved into the new laboratories of the Phipps' Institute in June 1908. In the temporary quarters previously occupied, the work was much interfered with by dirt and insects, and the move has given much needed relief from these. When some minor improvements are carried out, the section will be well-housed in its new quarters.

3. *Training.*—A mycological assistant for the United Provinces was under training until September 1907. Another for Bombay joined in June 1908, and the Assistant Professor of Botany, Poona Agricultural College, received a short course in April and May 1908. A mycological assistant for Madras joined in November 1908, and the Mycological Collector for Eastern Bengal and Assam joined in September 1908. A student from the Central Provinces received a course in cryptogamic

botany from July to September of last year, and again in plant anatomy from November to February. Two students from the Punjab undergoing a general course in agriculture, joined on the 1st June, 1909. The Assistant Mycologist, Bengal, who returned to Pusa in March, 1908, has remained in this laboratory pending the provision of accommodation for him at Bhagalpore. The prospects of assistants in the agricultural departments appear to have been hitherto insufficient to attract good men.

4. *Organisation.*—Much time has still to be given to organising the work particularly to meet the requirements of provincial departments. Collections have to be accumulated and worked out with what voluntary assistance can be got outside India. Duplicate collections will be, as far as possible, supplied to provincial departments which already have mycological assistants. Annotated specimens of Mildews and of Ascomycetes have been sent to Mr. Salmon of Wye College and to Messrs. H. and P. Sydow of Berlin, respectively, to be worked out for extension of the general survey of Indian parasitic fungi. Collections of diseased plants received from the Central Provinces, Bengal, Bombay, Burma and Madras, have been worked out and returned, and these will be gradually extended, as further material becomes available.

In the provinces, the question of the best means of expanding mycological work was considered by the Board of Agriculture which sat at Pusa in February, 1908. A small special staff of Indian assistants to be formed in each provincial department was recommended, their duties being defined as assisting the research work of the Pusa staff and conducting the training at the colleges. The ordinary staff of agricultural assistants should undertake such practical field work in preventing diseases as is necessary. In each province there will probably be appointed one assistant professor of mycology at the college and one assistant for work outside the central station. This will form a beginning which can be extended ultimately.

Arrangements have been made for unifying the proposed mycological course in the provincial colleges, and a memorandum on a course of lectures and practical work together with the most important diseases, has been compiled as a basis for this unification of mycological teaching.

5. *Research Work.*—A small number of diseases have been selected for detailed study which, in some cases, has continued over several years. The life-history and general biology of the parasites have been studied, and information obtained of their effects on the attacked plants. The following are the chief diseases specially investigated :—

6. *Sugarcane Diseases.*—Red rot is the chief of these. The work of the period under report has been directed to elucidating the methods of infection. It has given some new results, and it is hoped to publish a further contribution to the study of this disease during the year. In the Samalkota farm red rot is now quite rare in the crop, and this may be considered due to the methods of set selection advocated by this section. Work is in progress on the life-history of two other sugarcane parasites, but so far has not reached the publication stage. A few inoculations to ascertain the mode of infection of smut proved successful and these experiments are being continued this season.

7. *Palm Diseases.*—The campaign against the palm disease of the Godaveri delta is still being prosecuted, and the entertainment of the special staff employed has been recommended for a third year. The Imperial Mycologist inspected the work in September and December 1907 and in January 1909. There has been no general recrudescence of the disease in the early months of this year, such as occurred last year, and the Imperial Mycologist was struck by the very small number of newly diseased trees seen in his tour in January last. Under the new system inaugurated in October 1908, it is hoped that cutting work will go on continuously and simultaneously over the whole of

the affected area. Successful inoculations with the parasite have been secured, and a further study of its life-history made.

A serious disease of cocoanut palms was reported from Travancore early in 1907, and the Imperial Mycologist visited the State in September and October of that year to investigate its cause. A report on the disease has since been published.

8. *Diseases of Citrus Fruits.*—The chief of these investigated were "white rust" which has appeared at Poona, and a disease which is ravaging the valuable orange orchards of Sylhet and Lower Burma. The former is identical with a disease which has recently appeared in Southern Europe. Suggestions for experimental treatment have been made. The other disease does not appear to have been previously recorded. The Imperial Mycologist visited Burma in January 1908 to investigate it, and experiments are in progress to ascertain its cause. It appears certain that it can be avoided by grafting on stalks of other citrus plants.

9. *Wilt Diseases.*—These diseases have engaged more attention during the period under report than any others. Out of the considerable number, all similar in their course, which affect economic plants in India, those of cotton, indigo, pigeon-pea and gram were selected for study. In all, the fungus to which the cotton wilt of the United States is attributed was present, and the assumption was that this fungus which is said to be a virulent parasite in America, was the responsible agent in each case. Detailed experimental work has, however, thrown the gravest doubt on the parasitism of this species, and another organism was isolated from pigeon-pea which has been shown to be the cause of the disease in this crop. This organism has been called *Fusarium udum*, Butler. A memoir on the work is now in the press. The cause of the gram wilt disease has also been definitely determined, and successful infections obtained. The investigation has been lengthy and troublesome, but the diseases

referred to are amongst the most destructive in India and will well repay study. The experiments at Poona farm to raise a resistant strain of pigeon-pea, have been in progress four years and are promising well.

10. *Mulberry Disease of Kashmir.*—In a visit to Kashmir during the months of July, August and September, 1908, the Imperial Mycologist enquired into the diseases of mulberry and also those of apple, pear, peach, quince, cherry, apricot and grapevine. The results of part of this work have been published, and recommendations made for dealing with mulberry diseases. The study of the other diseases is in progress. A large collection of fungi was also made for the herbarium and these are being gradually worked out in the laboratory.

11. *Ginger Disease.*—This disease causing considerable damage in Eastern Bengal was investigated, and the probable cause of the disease determined. Experiments are still being carried out with the disease.

12. *Other Diseases of Plants.*—A new anthracnose of *val* (*Dolichos lablab*), some species of the rare genus, Choanephora, and the two maize smuts of India, have been studied, and a successful attempt has been made to work out the life-history of the very obscure paddy smut. As usual a large number of other diseases of crops were examined, and this work has formed a large portion of the routine work of the staff.

13. *Silkworm Disease.*—At the instance of the Imperial Entomologist an attempt was made to ascertain the cause of the heavy mortality amongst *eri*-silkworms during the hot weather of 1908 at Pusa. The mortality appears to be due to a specific disease allied to, but not identical with, that known as "flacherie" in ordinary silkworm.

14. *Programme for 1909-10.*—It is proposed to continue the work with sugarcane diseases and to publish a further contribution to our knowledge of red rot. If sanctioned by the Government of Madras, the palm disease campaign in the Godaveri delta will be continued. An account of

the parasite and a review of the work undertaken to prevent its spread will be published shortly.

It is hoped to complete during the year an illustrated account of the chief diseases of citrus fruit trees in India with suggestions for treatment.

It is proposed to continue the work on the wilt disease of leguminous crops, specially cow-pea, to determine the exact cause of the disease in each case.

The collection and identification of parasitic fungi will be continued. It is hoped to secure the publication of a complete list of the species of Ascomycetes in the Pusa herbarium.

It is hoped to complete the text of the book on Indian plant diseases during the year.

Students will be received for training, the regular course of instruction commencing on June 1st.

REPORT OF THE IMPERIAL COTTON SPECIALIST FOR THE YEARS 1907-09.

(G. A. GAMMIE, F.L.S.)

1. *Charge.*—Mr. Gammie joined the Imperial Department of Agriculture as Imperial Cotton Specialist on the 14th December, 1907, and has continued in charge of his office since. Until 10th October, 1908, when he was relieved by Mr. W. Burns, he held charge of the office of Economic Botanist, Bombay, in addition to his own duties, and from 6th August to 30th September, 1908, he held charge of the office of the Principal, College of Agriculture, Poona, owing to the illness of the Principal and the Professor of Agriculture.

2. *Tours.*—During the cold weather of 1907-08, the Imperial Cotton Specialist examined the cottons on all the farms of the Bombay Presidency and gave advice. In March 1908, he visited some farms in the Madras Presidency and discussed the experiments in progress with the Deputy Director of the northern division. During April and May an extensive enquiry was made regarding the varieties of cotton and the conditions under which the cotton crop is grown in Gujarat and Kathiawar. In Surat and Broach districts the quality of the cotton is best in the south and gradually gets worse as one proceeds northwards. Navasari has the finest and longest staple, then comes Surat and then Broach. This may be due to the heavier rainfall and greater atmospheric humidity at Navasari (owing to its proximity to the sea), for there is little apparent difference in the soil. Cultivators of the neighbouring districts have used Navasari seed, but, although the produce was ginned and despatched to Bombay separately, it failed to realise the same price as that obtained for cotton grown at Navasari. This may, however, have been due in part to the marks on the bales

showing that the cotton came from Broach and Surat. The two cotton varieties *Broach deshi* and *ghoghari* grown in the latter two districts are quite suitable to the tract, but it is absolutely necessary for the cultivators to maintain the purity of the seed. The growing practice of separating seed from the fibre in ginning factories, instead of as formerly by hand gins, has tended to injure the quality by mixing the seed. The average farmer gets his seed haphazard from the general supply at the ginning factory, good, bad, early, late, medium, tall, bushy and ordinary varieties all mixed. There can be no improvement, unless the seed is at least equal to the average of the previous crop. The improvement by selection of seed continued from year to year, is most important. If careful selection of seed is practised, and if the cultivator takes the trouble to handgin his seed at home, there is hope that the lint will be improved in quality and that the outturn per acre will also increase. In selecting the seed, cotton should be picked from the best sound bolls of large, healthy plants of branching habit of growth, each plant having a large number of bolls. Of the two varieties now growing in these districts the *Broach deshi* variety is the *standard*, and at present its price in the Bombay market rules that of all other cottons of India.

Kathiawar accounts for more than one-third of the total area under cotton in the Bombay Presidency (excluding Sind). Formerly *wagad* and *lalio*, two varieties of nearly the same quality as *Broach* (though picked less carefully, and, on that account, fetching a lower price), were the only ones found in Kathiawar, but on account of the succession of years of irregular rainfall, beginning with the famine year of 1900, they have been largely replaced by two inferior coarse varieties *mathio* and *navesari* (not Navasari) from Central India which give good yields, mature early and can be grown without much risk in years of scanty rainfall.

During the month of October, 1908, the Cotton Specialist visited the Punjab, Sind, Rajputana, Central

India and Gujarat. Throughout the four first named, the prevailing cottons are of *neglectum* type mixed with a plant resembling *bani*. If these two cross freely very close observation would be needed to establish the fact; that they remain, on the whole, true to type is easily demonstrated. The produce of these plants is probably the most inferior cotton in India which, however, fetches a price in advance of its intrinsic merits on account of its white colour and suitability for adulteration with wool. Throughout the area is found intermixed a superior style of cotton which has been already distinguished by the Cotton Specialist as *malvensis*. Officers of the provincial departments who are serving in coarse cotton tracts are already testing the feasibility of establishing this as a pure race, and Mr. Clouston of the Central Provinces is sanguine of ultimate success.

In the Punjab alone there is an annual variety of *arboreum* which the Cotton Specialist has already named *sanguineum*. It occurs chiefly as a *mixture* in the fields, and from a trade point of view there is no particular reason why it should be isolated, as its cotton is in no way different from that of the more common varieties. At the Lyallpur farm the Economic Botanist was engaged in studying a set of Punjab cottons, so that he could draw out a scheme for future work in selection. The experiments with upland Georgian and Egyptian cottons were of prime importance. The former is not of the New Orleans type, naturalised in the southern parts of Bombay and Madras, and which is intolerant of cold, but the true Upland which requires a distinct autumn for its development. Sales of this cotton have proved that a good price can be readily obtained for it, and since the officers of the Punjab Department have found in this a product far in advance of anything they can hope to attain from the selection of their indigenous varieties, it was gratifying to see that they were attending specially to the establishment of first class varieties of upland Georgian. They ought in this connection to carefully study the methods

employed in the United States. Of the chance of success for Egyptian cotton in the Punjab there is more doubt. The Bombay merchants consider that the Egyptian cotton grown in Sind is distinctly inferior to that directly imported from Egypt, and that from the Punjab would probably be no better.

In Sind the Cotton Specialist discussed the subject of cotton cultivation with Mr. Henderson, Deputy Director of Agriculture. The latter is of opinion that the very sanguine estimates formed on the results of trial sowings of Egyptian cotton, must be considerably modified in the light of recent results. He states that no further extension of the area suitable for growing Egyptian cotton can be counted on outside the Jamrao canal district until a further system of perennial canals is constructed, and that on the Jamrao canal a maximum of not more than 10,000—20,000 acres could be sown under favourable circumstances. Further, owing to scarcity of labour, occasional scarcity of water and the often alkali condition of the soil, the Jamrao cultivators prefer a surer, if less profitable, return in the cultivation of millets and short stapled indigenous cotton to giving the requisite care to the cultivation of Egyptian cotton. Despite the unsatisfactory results hitherto obtained, Mr. Henderson believes that good results can be got with Egyptian cotton when Egyptian methods of cultivation are closely followed. He lays special stress on very careful cultivation and rotation of the cotton crop with *berseem* (*Trifolium alexandrium*).

The American cottons, Texas Big Boll and Boyd's Prolific and also the acclimatised Dharwar-American, have been tested during the last year in Sind and have given promising results. They have a shorter growing period than Egyptian cotton, enabling them to be sown on inundation canals.

At the sewage farm in Karachi Spence cotton, Egyptian cotton and Sea Island cotton were tried with disappointing results. This was to be expected, as cotton is in no way a suitable crop for a sewage farm.

The Central Indian cottons consist only of *bani*, *jari* and *varadi*, with the usual preponderance of inferior types, and the remarks made on the Central Provinces cottons below will also apply to these.

In November, 1908, the Cotton Specialist visited Bassein in the Konkan to study the results of Bourbon cotton cultivation there, and then proceeded to Pusa to discuss various subjects with the Inspector-General of Agriculture in India and other officers of the Imperial Department. Afterwards a visit was paid to Bhagalpur, and cotton matters were discussed there with Mr. Woodhouse, Bengal Economic Botanist. Cotton is not, of course, an important crop in this Presidency, but the attention of the officers of the department might be drawn to the fact that *Gossypium intermedium* (according to the classification of the Cotton Specialist) is perhaps common as a garden crop in some parts. At least three separate plots were seen between Muzafferpur and Pusa, adjoining the railway. Sir George Watt, in his recent great work, states that the famous Dacca muslins were manufactured from one of the coarsest cottons in India, and he reproduces Roxburgh's coloured figure to support his point. From internal evidence it may be gathered that Sir George Watt was ignorant of the existence of *Gossypium intermedium*, because the picture he gives shows clearly a distinct form of this race. Some varieties in favoured localities may produce fine staple which is far more likely to be used in the manufacture of a superfine cloth than one which closely approaches the coarse Bengal or Assam type. There is no record of *Gossypium intermedium* being found anywhere in Eastern Bengal, but local officers may not have suspected its existence as a garden crop grown in villages near houses and not in the fields. The real source of the Dacca muslin cotton is a matter sufficiently important for close investigation.

The cultivation of *burhi* cotton in Chota Nagpur is probably capable of extension. Hand gins have been supplied by the Deputy Director of Agriculture, Bengal,

for the use of villagers. The cultivation of the cotton crop generally in Chota Nagpur is on the decline, owing to the restriction of the *dahu* system of cultivation. This system consists in burning thick layers of jungle on the land selected for the cotton crop. The land is thus fertilised with the ashes, and weeds are killed. If there is not enough jungle on the selected site, jungle including often valuable trees, is cut down at some distance and carried there. The system is a wasteful one, and its restriction cannot, therefore, be deprecated. Tree cottons are grown in the district to a limited extent. The plants give a fair return for three or four years after which their yields diminish.

During the same month a visit was paid to the Central Provinces and Berar Exhibition, and full advantage taken of such a favourable opportunity of studying samples of cottons from all parts of the province. Side by side with the experiments which are being conducted for the improvement of the local *jari* and *varadi* by the selecting out of a superior race known as *malvensis*, work of great importance has been done in the introduction of *burhi* cotton. The staple has been favourably reported on, but something further is required in the way of strength, and it is hoped the provincial department will attain this quality by selection. In the course of a conversation with an enterprising gentleman who cultivates about 1,000 acres of land near Yeotmal, it was learnt that *burhi* cotton is thoroughly at home in low lying ground where *jari* was killed by excessive rain in the last season. There is thus a chance for the introduction of *burhi* into areas of heavier rainfall, and Mr. Clouston has arranged to work out this point. It should not be grown, however, on the higher and drier lands which are exactly suitable for *jari*. Mr. Hemingway, Director of Agriculture, stated that a good deal of cotton wilt had been reported from the Satpuras, but he himself thinks that it is not really wilt, but damage caused by the heavy rainfall. He also stated that *bani* requires a heavier rainfall than *jari*, that the

cultivation of the former has declined owing to a long succession of abnormally dry seasons, and that with more favourable climatic conditions, *bani* will probably again come into favour. He also says that the *ryots* are quite alive to the necessity of selecting good seed and hand gin what is required for their own use.

In the adjoining tracts of the Nizam's territory, a particularly fine cotton known as *karkeli* is grown from its centre of trade. A quantity of the best *karkeli* seed cotton was obtained, and after ginning, was submitted to Messrs. Tata for opinion. They valued it as equal to fine Broach and further stated that the chief characteristic of the *karkeli* variety of cotton is its tension which is greater than that of any other variety of Indian cotton, and that it is greatly valued by the mills on that account. The Cotton Specialist has supplied seed to all parts where the coarser cottons are grown, and when samples of the produce are received, he will, if the results are promising, be able to arrange for its introduction on a larger scale. This cotton consists of *jari* of a very superior type with an admixture of *bani* and *upland Georgian*. It is even in staple and general characteristics. However the fact that inferior cotton is brought down from Central India for mixing purposes, is to be deplored.

At Barsi also a good type of cotton, mostly *bani*, used to be brought in from the Nizam's territory, but now, owing to the substitution of inferior varieties, its reputation has sadly diminished. It may be mentioned here that there is little direct proof of deterioration of the cotton plant anywhere in India, and that falling off in quality is greatly due to substitution of inferior varieties, or to mixture of good and bad varieties at the ginning factories. During January, 1909, the Cotton Specialist toured in Gujarat to study the factors of environment which influence the characteristics of the distinct varieties of cotton which exist there. Such a study may make it possible to formulate general laws for the production of different varieties of cotton.

Many of the Kathiawar States this year have gladly undertaken to carry out experiments with superior cotton, and there is hope that the former good varieties will again find a footing there.

The experiments with *Bourbon* cotton at Nadiad farm are very promising. Years ago partial success was obtained in its cultivation in the Kaira district, and the ultimate failure was perhaps due to the ignorance of the requirements of a perennial cotton which needs careful pruning among other details. Some of the samples of cotton were valued very highly. Mr. Spence might have obtained success further north at Deesa if he had tackled the problem in the right way. Some samples of Bourbon cotton from the Coimbatore district have been favourably reported on by a Bombay merchant.

Bourbon is probably the only foreign tree cotton worth experimenting with in India, and an attempt is at present being made to obtain sufficient information to enable definite schemes to be formulated for its cultivation on a larger scale. Its chief virtue at present seems to be that it is not suitable for ordinary cotton soil tracts where it would immediately suffer by admixture, but it would thrive on red and sandy soils where cotton is not a usual crop. In the Madras Presidency it is almost the sole memorial of the long defunct cotton department, and it has there suffered from long and unmerited neglect.

In February, 1909, the Cotton Specialist attended the Board of Agriculture meeting at Nagpur, and there discussed cotton matters with the officers interested. In March he toured through the southern Mahratta country, Madras Presidency and Bangalore where he advised the recently appointed Economic Botanist as to the experiments he should undertake.

In the previous year three Bombay cottons were reported as having given satisfactory results at Bellary. Broach, however, shows a steady decline. The peculiar yellow coloured cotton of the Madras Presidency is objected to

in the Bombay market where a white colour is one of the chief desiderata. A constant introduction of fresh seed would only partially remove the difficulty, as even in the case of cotton at Dharwar from imported seed, it was pointed out to Mr. Gammie that it was darker in colour. In the southern part of the Madras Presidency it has been proved that the *karangani* is superior to *uppam*, and steps are being taken to distribute quantities of the former. The introduction of the seed drill is considered the most important part of the work done.

From Burma intimation was received that the department had resolved to begin experiments; so, as a preliminary, sets of seeds of standard varieties were supplied in order that their behaviour might assist in arriving at some idea on what lines the trials should ultimately run.

3. *Collection of Varieties.*—A large collection of annual and perennial cottons, both indigenous and American, has been kept under observation at Kirkee and Ganeshkhind. The only tree cottons which gave any promise of success, were Bourbon and Spence cotton which is ordinarily indistinguishable from Bourbon.

4. *Distribution of Seed.*—Considerable quantities of cotton seed have been supplied, in all, to 47 persons in various parts of India.

5. *Identification and Valuation.*—A good many samples have been sent in for identification and valuation. All samples received for valuation were submitted to Bombay merchants, and the verdicts transmitted to the senders. An assistant recently appointed with a previous knowledge of cotton valuation, has studied the subject in Bombay and ought to prove of great help in the future in this line.

It is hoped to keep in close touch with cotton merchants. The Cotton Specialist has met and talked with a good many, and he feels that the trader and not the farmer is the chief obstacle in the way of improvement.

6. *Programme for 1909-10.*—It is proposed to tour in Eastern Bengal and Chittagong Hill Tracts in the autumn to advise on the possibilities of improvement of cultivation and introduction of suitable superior varieties. A visit may be paid to Burma later on. A scheme will be formulated for extended trials of Bourbon cotton, at least in the Madras and Bombay Presidencies. A tour will again be made in Gujarat to continue the investigation into the conditions which affect the production of cotton. This enquiry is also carried on wherever touring is done. The introduction of superior cotton into Kathiawar and of *karkeli* cotton into *jari* districts, will depend on the results achieved. Finally the Cotton Specialist is at the disposal of any one who may require his advice or assistance.

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REPORT

OF THE

Agricultural Research Institute and College, Pusa.

(Including Report of the Imperial Cotton Specialist)

1909-10

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Report of the Agricultural Research Institute and College, Pusa.

(Including Report of the Imperial Cotton Specialist.)

1909-10.

INTRODUCTORY.

IN presenting the report of the past year of the Agricultural Research Institute and College at Pusa, and that of the Imperial Cotton Specialist, I shall confine myself to a brief mention of the more important work undertaken in each section.

Agriculture.—The *Permanent Manurial and Rotation* experiments and the *Permanent Pasture* experiments have been continued according to the scheme described in the Proceedings of the Board of Agriculture, 1908. Sufficient time has not elapsed for making deductions from their results. Perhaps amongst the most useful work carried out is that of the preservation of fodder. In a country like India where cattle-food supplies are subject to the vicissitudes of an uncertain climate, this subject is of the highest interest. The production of ensilage on the American principle has been found the most satisfactory method of preservation. Maize was found to give the most nutritious food when thus prepared, but in point of yield per acre sorghum has given more weight and is therefore more economical. An objection to the American system of making ensilage in this country is the expense of constructing the silo. Experiments, however, are in progress

with a view of devising a cheap indigenous pattern which, if successful, will not only enable the better class of cultivator to adopt siloing, but will be of use perhaps to Government Departments in the preservation of fodder against famine years. As regards future work, that coming under the head of "Extension of Botanical Work" will doubtless prove the most important. The growth of selected varieties of wheats in extension of the work now being done by the Imperial Economic Botanist will be carried out on a practical scale with a view to still further extension in the future.

Botany.—No part of a scheme for the improvement of agriculture gives greater promise of success than that which deals with improvements emanating from the treatment of the plant. This is especially the case in India where not only are the plants of most crops degenerated specimens, but where the poverty of the cultivator makes improvement entailing the use of capital well-nigh impossible. By the introduction of a better plant, it is easily possible to increase yield and improve quality without adding to the cost of cultivation. The work which Mr. A. Howard, the Imperial Economic Botanist, is carrying out on *wheat* requires special recognition. The wheats which were sent home last year for testing have been found to rank in the same class as American and Canadian Spring wheats which command the highest price in the English market. It is almost needless to point out that these facts should have a most profound effect upon the export wheat trade of India. I desire here to record the appreciation felt for the invaluable assistance given by Mrs. Howard, who equally with her husband has accounted for the work of this Section.

Chemistry.—The principal work undertaken by this department during the past year has been the study of *Soil Gases* in relation to other constituents in the soil, the examination into the nature of *Usar* land and the investigations into the *Water Requirements of Crops.* The work of the first two is not in a sufficiently advanced stage to

need reference at this moment, but attention may be invited to Dr. Leather's work on the *Water Requirements of Crops*. In India where water is the prime factor underlying the successful growth of crops, its conservation and its economic use are of first rate importance. These remarks apply equally whether the water is derived from the monsoon rainfall or the irrigation canal. How much water is transpired by various crops, and during what period of growth does the crop require the principal portion of this water, are questions of as great importance to the agriculturist as to the irrigation engineer. In Chapter XI of the Report of the Indian Irrigation Commission, 1901-1903, the Commissioners remarked, "In the course of our investigations, we have been struck with the small amount of attention which appears to have been given by the Departments of Agriculture and Public Works to matters connected with the application of water to cultivated crops. At present, most of the information which can be had on these points has to be taken from papers published by the Agricultural Bureau in America. . . . . We consider it extremely desirable that expert enquiry should be directed to these important matters, which are so intimately connected with the development of irrigation."

This enquiry Dr. Leather has undertaken and in Memoir No. 8, Chemical Series, he has published the results of his work on the first section of the investigation, namely, that which deals with the total amount of water transpired by the crop and the period of growth during which the greater part is assimilated. The ratio between the amount of water transpired and the ultimate weight of dry crop is worked out for most of the principal Indian crops.

Entomology.—One of the principal features of the work of this section is the attention which is being paid to industries that depend upon the products of insects. Thus Eri, Mulberry and Tussar silk and the cultivation of Lac are taking up much of the time of Mr. Maxwell-Lefroy, the Imperial Entomologist, and his staff. The Eri silk industry

has spread considerably in Tirhoot, Bhagalpur and Patna, where owing to their proximity, these places are under the direct influence of this Institute. It is also to be found in Malabar, Dharwar, the West Coast, Gujarat, Kathiawar, Sind, Patiala, Rohilkhund, Betul, Chanda and Murshidabad. Progress is at present somewhat retarded by the want of middlemen for collecting the cocoons from the rearers and conveying them to the mills, but it is expected that enterprise will eventually overcome this difficulty.

Mycology.—The investigation into the *Blister Blight of Tea* carried out by Mr. W. McRae while he officiated as Imperial Mycologist, has been the most important new work undertaken during the year. The disease which has been known for years in North-East Assam appeared for the first time in Darjeeling in 1908. In 1909, it extended, and this led to the Darjeeling Planters' Association asking the assistance of this Institute. It has spread still further this year into the Dooars and the Terai and its progress will be watched with anxiety by all interested in tea.

The *Palm Disease* in the Godavery Delta has not ceased to engage the attention of this Department, and recommendations have been made for continuing the work of repression, especially in the Kistna District where, in spite of the repeated warnings of the Imperial Mycologist, it was being neglected. A full account of the disease and measures taken to check it is in the press and will appear shortly.

Bacteriology.—It is only necessary to mention that with the appointment of Mr. C. M. Hutchinson as Imperial Agricultural Bacteriologist, this section has been opened during the year. The importance of the study of the biological aspect of soils in this country cannot be overestimated, and much useful information is anticipated from investigations in this quarter.

Cotton.—The importance of the cotton plant not only to India but to the British Empire has led the Government

to appoint a whole-time officer for this particular crop. Mention may here be made of the more important recommendations of the Imperial Cotton Specialist which will be found embodied in his report in greater detail. In *Eastern Bengal and Assam*, the prevalent type is that known as *Gossypium neglectum* var. *Assamica* of Watt and is commonly called the Garo Hill Cotton. It is not used in commerce as cotton but as a substitute or adulterant in wool manufacture and any attempt to improve it from the point of view of the cotton merchant would result in a serious diminution of price. The Imperial Cotton Specialist recommends that in any experiments carried out by the Department, this type of cotton should be adhered to, lest the experience of generations which has taught the use of a kind of cotton capable of growing under excessive rainfall and the primitive agriculture of the Hill tracts, be lost and the present variety substituted by an unsuitable one. He, therefore, advises that trials should be confined to improving in this one type, the length of staple and the percentage of cotton to seed but that no attempt should be made to alter the special characteristics of the product.

In *Bengal* the cottons appear altogether to be of an inferior type. Trials should be confined in this Province to the possibilities of *G. intermedium* and *G. hirsutum*, the latter preferably in its two forms of *Buri* and Cambodia.

In the *Central Provinces*, it is pleasant to find that Mr. Clouston, Deputy Director of Agriculture, has selected a plant of the *Buri* variety which is promising well and that most valuable work is being done in these provinces by the introduction of *Buri*. The recommendations of the Imperial Cotton Specialist in regard to these provinces may be summarised as under :—

(1) The introduction of *Buri* to accompany *Bani* but not to oust *Jari*.

(2) The improvement of *Bani* in its percentage of cotton.

(3) The isolation of the different types of *Jari*.

The report of the Imperial Cotton Specialist so far as other Provinces are concerned does not call for any comment.

Publications.—In addition to the Agricultural Journal of India, the Memoirs of the Department of Agriculture in India, Bulletins and Leaflets, two publications of importance have issued from the Institute during the past year, namely, *Indian Insect Life* by Mr. Maxwell-Lefroy assisted by Mr. F. M. Howlett and *Wheat in India* by Mr. and Mrs. Howard. *Indian Insect Life* containing 786 pages of printed matter and 619 illustrations has been well received both in India and abroad and is without doubt the most advanced and comprehensive manual of Indian insects yet published. *Wheat in India* containing 288 pages and 18 illustrations, deals in a complete manner with the production, varieties and improvement of Indian wheat. In order to be useful to all interested in the various aspects of wheat production, the scope of the book has been made as wide as possible.

Students.—Out of the students admitted in the previous year, nine continued their course and of these seven left during the year after the completion of their training and one was recalled to his province before the expiry of his term. Four new students were admitted during the year, *viz.*, one each in Chemistry, Mycology, Entomology and Agriculture. In the short practical courses in Agriculture, Fruit-growing, Silk-culture, Lac cultivation, Cattle Breeding and Management and the like, 39 students were admitted, some of whom took up more than one subject.

BERNARD COVENTRY,
Offg. Inspector General
of Agriculture in India.

SIMLA;
The 1st October 1910.

REPORT OF THE DIRECTOR, AGRICULTURAL RESEARCH INSTITUTE AND COLLEGE, PUSA, FOR THE YEAR 1909-1910.

(E. J. BUTLER, M.B., F.L.S.)

1. *Charge of Office.*—Mr. B. Coventry held charge of the office of Director up to the 9th May 1910, with the exception of one month in September-October 1909, when he was on privilege leave and Mr. H. Maxwell-Lefroy, M.A., F.E.S., F.Z.S., Imperial Entomologist, acted for him during his absence in addition to his own duties. In consequence of his appointment as Officiating Inspector General of Agriculture in India, Mr. Coventry relinquished charge of the office of Director on the 9th May 1910, and I was appointed to officiate for him in addition to my own duties.

2. *Staff.*—Dr. J. Walter Leather, Ph.D., F.I.C., F.C.S., Imperial Agricultural Chemist, returned from leave on the 27th October 1909 and took over charge of the chemical section from Mr. H. E. Annett. The latter has been deputed to act as Agricultural Chemist, United Provinces, from the 3rd November 1909. The charge of the mycological section was taken over by me from Mr. W. McRae, M.A., B.Sc., on the 27th December 1909, when I returned from leave, and immediately after Mr. McRae proceeded to Madras to join his new appointment as Mycologist to the Government of Madras. His successor, Mr. F. J. F. Shaw, B. Sc., A.R.C.S., joined his appointment as Supernumerary Mycologist on the 28th January 1910. Mr. C. W. Mason, Supernumerary Entomologist, left the Department on the 19th December 1909, and Mr. T. Bainbrigge-Fletcher, R.N., F.E.S., joined this Institute as Supernumerary Entomologist on the 8th April 1910. The Second Imperial Entomologist, Mr. F. M. Howlett, B.A., F.E.S., has been on leave since the 9th September 1909 and

is expected to return in January next. Mr. C. M. Hutchinson, B.A., joined the Department on the 24th December 1909, as Imperial Agricultural Bacteriologist. The charge of the Farm was relinquished by Mr. E. Shearer, Imperial Agriculturist, on the 17th July 1909, in consequence of his promotion to the post of Assistant Inspector General of Agriculture in India and the Director was placed in charge of the duties of the Imperial Agriculturist in addition to his own duties. Mr. G. C. Sherrard, B.A., Supernumerary Agriculturist, was appointed to be Assistant Agriculturist with effect from 17th July 1909. He was on privilege leave from 2nd to 20th November 1909, and from 6th June 1910 to 6th July 1910. Mr. A. McKerral, M.A., B.Sc., who has been appointed Assistant Inspector General of Agriculture in India, *vice* Mr. E. Shearer, resigned, has been lent to the Pusa staff to undertake the work of Imperial Agriculturist under the Director as a provisional measure. He joined his duties at this Institute on the 19th June 1910. The botanical section was in charge of Mr. A. Howard, M.A., A.R.C.S., F.L.S., up to 30th April 1910, when he proceeded on leave to England. Mr. G. P. Hector, M.A., B.Sc., Supernumerary Botanist, was transferred to Eastern Bengal and Assam on the 14th July 1909, and the services of Mr. E. Holmes-Smith, B.Sc., Economic Botanist designate of Burma, were transferred to this Department with effect from the 15th July 1909, for appointment as Supernumerary Botanist. The latter has been on deputation in the Bombay Presidency since the 6th March 1910, to acquire experience of work in a province.

The European Scientific Staff of the Institute consisted of the following :—

(1) The Imperial Agricultural Chemist with one Supernumerary, (2) the Imperial Mycologist with one Supernumerary, (3) the Imperial Entomologist with one Supernumerary, (4) the Imperial Economic Botanist with one Supernumerary, (5) the Second Imperial Entomologist, (6)

the Imperial Agricultural Bacteriologist, (7) the Assistant Inspector General of Agriculture in India (temporarily in charge of the agricultural section) with the Assistant Agriculturist.

During the year under report, the pay and position of several of the senior Indian assistants of the institute were improved and the first assistants in each section as well as other assistants engaged in teaching and research work have been admitted to gazetted rank.

3. *Scientific Work.*—The scientific work of the Institute during the year is indicated in the reports of the various Sections.

4. *Buildings, Grounds, etc.*—In consequence of the transfer of the head-quarters of the Inspector General of Agriculture in India to Pusa, two blocks of new quarters have been departmentally constructed for the use of his staff and in addition some old buildings have been placed at his disposal. The grounds surrounding the College building have been fully laid out and arrangements made for irrigating the lawns.

5. *Students.*—Out of the students admitted in the previous year, 9 continued their course and of these 7 left during the year after the completion of their training and one was recalled to his province before the expiry of his term. Four new students were admitted during the year, *viz.*, one in Chemistry (an Assistant of the Agricultural Chemist, United Provinces) for a three months' course, one in Mycology (a private student from Bombay), one in Entomology, from the Central Provinces Department of Agriculture, and one for a general course in Agriculture from the Punjab Department of Agriculture. The private student in Mycology has, however, abandoned the course and left the Institute. There were at the end of the year four students under training, *viz.*, one in Chemistry, two in Entomology and one for a general course.

The short courses in practical agriculture and in other allied practical subjects inaugurated last year at Pusa

were continued. The number of students admitted to the various sections for these courses was as follows:—Six in fruit-growing, eighteen in silk-culture, ten in lac cultivation, nine in cattle breeding and management, three in poultry management and three in tillage implements and agricultural machinery. The students for these courses came from different parts of India and some of them took up more than one subject.

6. *Publications.*—This work has been continued. During the year under report two new books, one "Indian Insect Life" by Mr. H. Maxwell-Lefroy, Imperial Entomologist, assisted by Mr. F. M. Howlett, Second Imperial Entomologist, and the other "Wheat in India" by Mr. A. Howard, Imperial Economic Botanist, and Mrs. Howard, were published in addition to the Agricultural Journal of India, the Memoirs of the Department of Agriculture in India, Bulletins and Leaflets.

7. *Library.*—The revised catalogue of the library is still in the press. Over a thousand volumes have been added to the library during the year.

8. *General Health of the Station.*—The general health of the station during the year under report was good, excepting in the monsoon period. Relief was afforded in the hospital to 6,231 new cases, of which 6,015 were treated in the outdoor department and 216 admitted as indoor patients. These figures show an increase of 2,918 and 112 respectively over last year's totals. The increase in attendance was due to the greater prevalence of malarial and allied fevers during the months of July, August and September, 1909. 99 cases amongst European officers and their families were attended to.

The daily average number of patients treated was 6·96 indoor and 48·97 out-door as against 4·68 and 25·05 respectively during the previous 12 months.

Five deaths occurred in hospital—two cases from pneumonia in aged and debilitated subjects, one from malarial cachexia and two from *Kala-Azar*.

Eighty-eight surgical operations were performed, of which 4 were major and the remainder minor.

The prevailing diseases were malarial fevers, bowel complaints and rheumatic and skin affections. Malarial fever cases were diagnosed microscopically before treatment.

There were no cases of infectious diseases, except a case of chicken-pox (imported). Eight primary and three revaccinations were performed in the early part of the year.

9. *Accounts.*—The total expenditure incurred during the year was Rs. 3,12,427 as against Rs. 3,23,900 of the preceding year. The principal items of expenditure are pay of gazetted officers and establishment Rs. 1,78,680, travelling allowance of officers and establishment Rs. 14,699, publications Rs. 30,000 and farm expenditure, scientific apparatus, books, contingencies, etc., Rs. 89,048.

The gross receipts during the year by sale of farm produce, milk and other miscellaneous articles amounted to Rs. 5,573 as against Rs. 9,680 of the preceding year. The decrease is due to the abnormal rainfall (amounting to 72 inches) which damaged the crops.

REPORT OF THE IMPERIAL AGRICULTURIST FOR THE YEAR 1909-10.

(A. McKERRAL, M.A., B.Sc.)

1. *Charge and Establishment.*—Mr. Ernest Shearer, Imperial Agriculturist, relinquished charge of the farm on 16th July 1909 on his promotion to the post of Assistant Inspector General of Agriculture in India, and his duties were taken up by Mr. Bernard Coventry, the Director, Agricultural Research Institute, in addition to his own work. Mr. G. Sherrard, who had previously acted as Supernumerary Agriculturist, was appointed Assistant Agriculturist. Amongst the subordinate staff, Mr. G. N. Desai, First Farm Overseer, was transferred in March 1910, to the Agricultural Department of the Bombay Presidency, and Mr. Ikramuddin, the Second Farm Overseer, was promoted to First Farm Overseer in his place. Mr. Ziauddin Hyder, fieldman, was in charge of the Poultry until promoted in April 1910 to the post of Second Farm Overseer, Mr. Nizamuddin Hyder being appointed in his place. Mr. Judah Hyam, the Veterinary Overseer, remained in charge of the breeding herds as before. During the year, the Government of India were pleased to raise him to Gazetted rank along with certain other Indian Assistants of the Institute.

2. *Training.*—The two students Bhai Sunder Singh and Bhai Kharak Singh, sent by the Punjab Agricultural Department for a general course of agriculture, completed their training and returned to their province to take up respectively the posts of Assistant Director of Agriculture and Assistant Professor of Agriculture. A third student, Chowdhuri Fateh-ud-din, sent by the same department, was admitted to a general course in agriculture from 18th August 1909.

Short courses in cattle breeding and management, poultry management, tillage implements, and agricultural machinery were given to some 15 students.

3. *Character of the Season.*—The rainfall for the season amounted to 72 inches, which is some 30 inches above normal. It was very badly distributed and was precipitated at times in such large quantities that the crops became injured. The result of the monsoon harvest was consequently a disappointment and the yields in no way approximated to expectation. The rain, too, was unusually heavy in the month of October, which not only retarded the preparation of the land for the *rabi* season, but caused unprecedented sickness amongst the labourers.

4. *Cropping.*—The trials with many varieties of sugarcane were continued as in previous years. In spite, however, of the care and control with which the cultivation and selection of this crop was carried out, the results were disappointing. It has been realised that the locality is unsuited to the growth of thick canes such as were being cultivated and with the exception of a small area reserved for the Mycologist and Entomologist the cultivation of this crop has been abandoned. Jute and flax have been grown for experiments for the Fibre Expert to the Government of Eastern Bengal and Assam with varying degrees of success. With regard to jute, the experiments were mostly for the purpose of determining the botanical characters in a collection of specimens. While this crop grows well in these districts, it is generally recognised that it does not do so well as in Eastern Bengal and its cultivation amongst the cultivators of Behar is not extending. With regard to flax, prospects appear promising provided the crop is grown in the best possible way, that is to say in strong land with an abundance of moisture. The work in this crop is being extended, and the experiments now in progress should solve most of the doubts and difficulties which prevent its being more generally adopted. In addition to the usual cultivation of rice carried out on the farm, the use of bone meal and saltpetre was tried in a series of $\frac{1}{4}$ acre plots. Two alternate plots were unmanured and the other two manured with 30 seers

of saltpetre and 3 maunds of bone meal per acre. The results were as under :—

	Mds	Seers.	
(1) Manured	30	17	per acre.
(2) Not manured	26	22	,,
(3) Manured	29	5	,,
(4) Not manured	26	4	,,

The result is slightly in favour of the manured plots, but the difference is not sufficient to warrant the expenditure. The remainder of the crops on the farm were grown mainly for the purpose of fodder for the increasing numbers of cattle. These crops consist chiefly of maize, sorgum, *arhar* (*Cajanus indicus*), and oats. A large number of varieties of crops in small plots were grown for the use of the Entomologist and Mycologist. The brick-field area, brought under cultivation for the first time, was sown with a mixed crop of rice, sorghum, and *moong* (*Phaseolus mungo*), and gave quite satisfactory results.

5. *Permanent Manurial and Rotation Experiments.*—These have been continued according to the scheme described in the Proceedings of the Board of Agriculture, 1908. Sufficient time has not elapsed for making deductions from these experiments.

6. *Permanent Pasture Experiments.*—The series of permanent pasture experiments laid down in the monsoon of 1907, according to the scheme described in the Proceedings of the Board of Agriculture held at Pusa in February 1908, has been maintained. The experiments aim at determining the effect of different manurial dressings (1) on the total yield of the herbage and (2) on its quality and botanical composition. So far as yield is concerned, it is much too early as yet to make any deductions, especially as the first two seasons during which the experiments took place were not normal with respect to rainfall. With regard to the quality of the herbage also, sufficient time has not elapsed for radical changes to have taken place. In fact, as the total number of species of grasses and legumes which were originally present was small, it is

scarcely to be expected that such complete alteration of the flora as has characterised similar experiments in Europe may be looked for in the case of Pusa. The condition of the plots at present may be summarised as follows :—

In the cold weather, they consist mostly of *Apang* (*Andropogon annulatus*) with a certain amount of *dubh* (*Cynodon dactylon*) and in the rains, of Digitaria and Rottboelia. At the end of the rains, the whole area is overgrown by *rari* (*Saccharum spontaneum*) and *dabhi* (*Imperata arundinacea*) which disappear entirely during the cold weather. The only legumes worthy of notice are *Medicago lupilina*, Linn., and *Indigofera linifolia*, Retz., both of which are " bottom " plants, useless for hay purposes. Weeds are practically a negligible quantity. On the whole, the composition of all the plots is as yet practically the same.

7. *Fodder.*—The supply of fodder for the cattle is one of the chief objects of the farm, and consequently by far the larger portion of the arable area is devoted to this purpose. Maize, sorghum, *arhar* (*Cajanus indicus*), and oats are the crops found most suitable. Ensilage is much resorted to, and if the process is properly carried out in silos of the American type, it is invariably a success. Maize probably gives the most nutritious food when thus prepared, but in point of yield per acre sorghum is more satisfactory and therefore more economical. The amount of silage made last year on the farm was 13,329 maunds.

8. *Breeding.* (*a*) *Cattle and Sheep.*—The Montgomery herd of cows continues to do well and its numbers have been increased. There are 62 cows, 3 bulls, and 108 young stock. The local herd of cattle which was maintained for the Bengal Government have been removed to Bettiah where they are being looked after by the Bengal Agricultural Department. This has given us more room for the extension of the Montgomery herd. The flock of 80 Bikanir sheep which were purchased two years ago have not done well. The change from an excessively arid to a humid tract caused a breakdown in their constitution and the

majority have died. The remainder will be got rid of, and in their place is being substituted a flock of Gorakhpur ewes which are good specimens of the local breed. These are at present doing well. It is intended to cross them with Dumbha rams with a view to improvement for mutton purposes.

(*b*) *Poultry Breeding.*—This work is now being conducted on a fairly large scale. The stock consists of 18 pens of fowls nearly all of pure breeds, one pen of Mammoth Bronze Turkeys, and one flock each of Embden Geese and Aylesbury ducks. The object is to supply at reasonable prices fresh blood of imported strains to Provincial Agricultural Farms and private individuals who are unable to afford the expense and risk of direct importation. This is effected either by egg distribution or by sale of birds. The price of eggs is Rs. 6 a dozen and birds are Rs. 30 for an adult trio and Rs. 16 for half grown birds. The eggs are sent by post or by rail in boxes specially made for the purpose, but it has to be acknowledged that this mode of distribution has not, by any means, been successful. The percentage of successful incubation from eggs transmitted by post or rail was extremely low, indeed so low that this method had to be discontinued. The failure is due doubtless to the fact that distances are so great in India, and the Postal and Railway authorities so unaccustomed to handling delicate articles like eggs, that the jolting and rough treatment in transit must have destroyed their fertility. The distribution of birds may be taken to have been altogether a success even in the case of long distances. The varieties of fowls which at present have done best are the Partridge Wyandotte, White Wyandotte, White Orpington, and Barred Plymouth Rocks. The Mammoth Bronze Turkeys have also done very well.

9. *Programme of work for 1910-11:*—1. *Permanent Experiments.*—The permanent manurial and rotation experiments and the pasture experiments will be continued.

2. *Extension of Botanical work.*—The growth of selected varieties of wheat will be taken up in extension of the

work now being done by the Imperial Economic Botanist. This work will be carried on in consultation with, and under the botanical surveillance of, the Imperial Economic Botanist.

3. *Cattle Breeding*.—The local herd has been transferred to the Bengal Agricultural Department and the Montgomery herd will now be considerably increased. Improvement of this breed by selection based principally on milk tests will be the chief object in view.

4. *Sheep*.—The crossing of Gorakhpur ewes with Dumbha rams will be undertaken.

5. *Poultry*.—Poultry breeding and distribution will be continued.

6. *Training*.—Courses in cattle breeding and the management of poultry will be given as heretofore.

REPORT OF THE IMPERIAL ECONOMIC BOTANIST, FOR THE YEAR 1909-10.

(A. HOWARD, M.A.; A.R.C.S.; F.C.S.; F.L.S.)

Part I.

Teaching, Training and Staff.—Two Supernumerary Botanists were in training during the year under review. Mr. G. P. Hector, M.A., B.Sc., the Economic Botanist-designate of Eastern Bengal and Assam, proceeded to that province on July 14th, 1909. Mr. E. Holmes-Smith, B.Sc., Supernumerary Botanist, worked at Pusa till February last when he proceeded to Bombay.

Five students attended the course on fruit growing and in addition, there were four students who attended special courses. One further short-course student was sent for a few weeks by the Economic Botanist to the Government of Bengal.

Mr. Ijaz Husain, Manager of the Lyallpur Farm, gave up his post in the Punjab Agricultural Department so as to become trained in this section as third assistant. My second assistant, Mr. Abdur Rahman Khan, has continued his training in Economic Botany in the section. I have pleasure in reporting the continued progress made by this assistant who, I believe, possesses real aptitude for and a thorough interest in Economic Botany. He is the joint author of an important memoir on some aspects of plant breeding in India recently submitted for publication.

While all other members of the staff have improved in their work, the services of my clerk, Ram Nechhawar Lal and of my second fieldman, Sarup Singh, deserve mention.

Part II.

Investigations.

Wheat.—I am able to report very considerable progress in the wheat investigations of this section along several lines.

The expectations foreshadowed in Pusa Bulletin No. 14 on the possibility of growing stronger wheats with better milling qualities than those now exported from India have been abundantly realised during the past year. A further set of Pusa selected wheats was sent to Mr. Humphries for milling tests. Several of these wheats were found to possess great strength and high milling qualities and to be of the same class as American and Canadian Spring wheats which command the highest prices on the English market. The results of this work are published in Pusa Bulletin No. 17.

The results obtained during the year on the influence of the environment on the quality of wheat have been submitted for publication as a memoir. This work, which is being conducted in collaboration with Mr. H. M. Leake, Economic Botanist to the Government of the United Provinces, has been greatly extended during the past year. While it has been proved that environment influences quality, the most practical outcome of this work is the discovery of the fact that the quality of any wheat depends largely on the proper and efficient preparation of the land and that canal irrigation does not necessarily injuriously affect the milling qualities of wheat. It is expected that great consequences will result from these investigations and that they will be the means of opening a new chapter in the production of wheat in India and in the agricultural practices of the Indo-Gangetic plain.

The Monograph on Indian Wheat has been published during the year. While going through the press, it was necessary to add a considerable amount of new matter so as to bring it up to date. The book represents the results of the preliminary work on wheat which has been done at Pusa during the last four years and will, I trust, be of use to students and some members of the Agricultural Department.

The investigations on the natural crossing of wheat in India have been written up and incorporated in a memoir.

It has been proved that under canal irrigation in the Punjab, crossing is exceedingly common, a fact which will render seed distribution and wheat breeding work at Lyallpur somewhat difficult.

Many of the new Pusa selections and also some of the new hybrid wheats were grown on quarter acre plots at Pusa this year. As no rain fell during the growing period and as no irrigation water was applied, the crop derived its moisture from the water stored up in the soil from the previous monsoon. The yields varied from 25 maunds in the case of early varieties to 35 maunds per acre in the case of the later sorts and some of the new hybrids. About 2·5 tons of straw to the acre were produced. These yields are unprecedented for India and were possible on account of the system of cultivation and dry-farming employed in the Botanical area at Pusa.

Fruit.—The results so far obtained in fruit-growing at Pusa have been published in Pusa Bulletin No. 16. A visit was paid to Quetta during the year and proposals have been put forward for developing the fruit investigations of the section.

Tobacco.—The results of the tobacco investigations have been published in two memoirs on the subject which form a basis for further work. Natural crossing is common in the crop but easily prevented by raising seed under bag which gives rise to uniform crops. Some preliminary curing experiments have been conducted in conjunction with the Peninsular Tobacco Company with both American and Indian varieties. The Pusa varieties have given the best results so far.

Fibres.—A good deal of work has been done on *Hibiscus cannabinus*, but I have been unable to find time to write up the results. A memoir on *san* (*Crotalaria juncea*) has been published in which the beneficial effect of this crop as a green manure for tobacco has been described.

General.—A large amount of work on the occurrence of natural cross-fertilization in India has been written up

as a memoir and submited for publication. The significance of this work both from the point of view of plant breeding and from that of seed distribution has been emphasised.

Programme of work for 1910-11.—1. *Training.*—The training of advanced students in this section will be continued on the lines laid down in the prospectus of the Institute. The course on fruit-growing will be given as usual in the cold weather.

2. *Plant breeding and plant improvement.*—During 1910, the following crops will be studied :—wheat, tobacco, barley, oilseeds and fibre plants.

(*a*) *Wheat.*—The botanical survey of the wheats of Baluchistan will be completed. The production of improved varieties by selection and hybridization will be continued. The co-operative experiments on the effect of environment on the milling and baking qualities of Indian wheats, which are being conducted in collaboration with Mr. H. M. Leake, Economic Botanist to the United Provinces, and of which the earlier results are now in course of publication, are being continued on an extended basis. The above experiments include the effect of weathering on the quality of the wheat crop and the Imperial Bacteriologist has agreed to undertake the study of the bacteriological aspect of this subject.

(*b*) *Tobacco.*—The production of new varieties by selection and hybridization will be continued as well as the testing and curing of the varieties already isolated. The investigations on the influence of environment on the stability of the type and on the quality will continued.

(*c*) *Oil-seeds.*—The study of the oil-seeds of India will be continued on similar lines to those adopted in the investigations on wheat.

(*d*) *Fibres.*—The isolation and testing of pure races of the fibre plants of India will be continued.

(*e*) *Fruit.*—The fruit experiments will be continued on the lines laid down in the First Fruit Report.

(*f*) *Minor Investigations.*—The study of the varieties of cassava will be completed and the investigation on the inheritance of sex in *Ganja* continued.

Publications.—The following books and papers have been published and written during the year :—

Report on Economic Botany for the Board of Scientific Advice, 1909 (in the press).

The Milling and Baking Qualities of Indian Wheats, No. 2. Some new Pusa Selections tested in 1909 (with G. L. C. Howard). *Bulletin No. 17 of the Agricultural Research Institute, Pusa.*

Second Report on the Pusa Fruit Experiments, *Bulletin No. 16, Agricultural Research Institute, Pusa.*

The Fertilising Influence of Sunlight (with G. L. C. Howard). *Nature,* February 17th, 1910.

Studies in Indian Tobaccos. No. 1. The types of *Nicotiana rustica* L. Yellow-flowered tobacco (with G. L. C. Howard). *Memoirs of the Imperial Department of Agriculture* (*Botanical Series*), Vol. III, No. 1.

Studies in Indian Tobaccos. No. 2. The types of *Nicotiana tabacum* L. (with G. L. C. Howard). *Memoirs of the Imperial Department of Agriculture* (*Botanical Series*), Vol. III, No. 2.

Studies in Indian Fibre Plants. No. 1. On two varieties of *Sann, Crotalaria juncea,* L. (with G. L. C. Howard). *Memoirs of the Imperial Department of Agriculture* (*Botanical Series*), Vol. III, No. 3.

The Influence of the Environment on the Milling and Baking Qualities of Wheat in India. No. 1. The results of 1907-08 and 1908-09 (with H. M. Leake and G. L. C. Howard). *Memoirs of the Imperial Department of Agriculture* (*Botanical Series*), Vol. III, No. 4.

The Economic Significance of Natural Cross-fertilization in India (with G. L. C. Howard and Abdur Rahman Khan). *Memoirs of the Imperial Department of Agriculture* (*Botanical Series*), Vol. III, No. 6 (in the press).

Wheat in India, its varieties, production and improvement (with G. L. C. Howard). Published by Thacker, Spink and Company, Calcutta.

REPORT OF THE IMPERIAL AGRICULTURAL CHEMIST, FOR THE YEAR 1909-10.

(J. WALTER LEATHER, PH.D.; F.I.C.; F.C.S.)

Charge of Section.—Mr. H. E. Annett, B.Sc., M.S.E.A.C., Supernumerary Agricultural Chemist, was in charge of this section until October 27th when I returned from leave.

Meteorology.—In addition to the usual temperature, humidity, etc., records, an evaporimeter has been constructed and the data will prove of service to both the Meteorological and Irrigation Departments. The first instrument employed, a self-recording one, proved to be defective, chiefly because the atmospheric dust of the hot weather accumulated in the working parts. A much simpler and quite reliable instrument was kindly supplied to me by the Chief Engineer, Punjab Irrigation Branch, and reliable data can now be obtained, though the record is not self-maintained.

Drainage data.—The records of drainage under conditions of both bare-fallow and cropped soil at Cawnpore and Pusa are now bearing fruit and the first few years' results will be put together for publication at the close of the present monsoon. In addition to the quantities of water which percolate, evaporate or run off the land respectively, information regarding the period of most active nitrification, as also the effect of crops on nitrification is being gleaned. This subject is not entirely novel, M. Dèherain having published information in respect of it some 15 years ago, but it has not generally been acknowledged as important. The crops, wheat and maize, which were grown on two of the Pusa gauges, depressed in some way or other the formation of nitrates last year very materially.

Water requirements of crops.—The first section of this investigation was published during the year as Memoir

No. 8, Chemical Series, and dealt with both the total amount transpired as also the period during which the greater part was assimilated. The effects of temperature and humidity, proportion of water in the soil, manure, the nature of the crop, etc., were dealt with. One of the most important of these is manure, which whilst increasing the weight of the crop and consequently the amount of water required, effects an economy of the latter since the increased requirement of water is proportionately less than the increase in crop. Good tillage probably has a similar property. The second section of the investigation has to do (*i*) with the effect of different soils and (*ii*) with the results of field tests; this will be published shortly.

Soil Gases.—The first section of work in connection with the subject of soil gases dealing with the relations of carbonic acid to calcium carbonate and water, has been published as Memoir No. 7, Chemical Series, and it is expected that a second section dealing with the similar relations to magnesium carbonate will be published in the course of the cold weather.

Usar land.—At the request of the Deputy Director of Agriculture, Central Circle, United Provinces, an investigation into the nature of some land which has been going out of cultivation in the Mainpuri District, has been commenced and has indeed absorbed so much time that no less than three or four of the assistants are at present utilised for it.

The soil is Usar, of the "black alkali" type, but the amount of alkali present was thought at first to be too small to account for the sterility. The sub-soil water level has risen seriously of late years and no doubt was felt that this was one of the primary causes of the trouble. But in addition to this, preliminary tests showed that the soil is so highly impervious to water that this feature alone might account for sterility. All, or at least nearly all, the water assimilated by plants must move through a certain amount of soil before it comes in contact with the root; such distances may only be a few inches or centimetres,

but this feature of the process must nevertheless be recognised; and if the amount of water moving to the root in a given time is too small for the nourishment of the plant, there may be abundance of water in the soil, and yet unable to reach the roots sufficiently quickly; the plant's energy would thus become reduced, and the crop might die off altogether.

There were thus three distinct questions involved, namely, (*i*) the high sub-soil water level, (*ii*) the alkali in the soil, and (*iii*) the impervious nature of the soil. The investigations which are being conducted at Pusa have to do with Nos. (*ii*) and (*iii*) of these questions.

In order to study the subject in the field as far as possible, Mr. S. C. Kar, M.A., the second assistant, was deputed to work under the instructions of Mr. B. C. Burt, Deputy Director of Agriculture, United Provinces, at Bhadan, where a temporary laboratory was fitted up. Here the amounts of alkali and water were determined in the soil at specific points, in every 6 inches depth down to 7 feet or 8 feet from the surface, until the middle of May, when this part of the work was transferred to Pusa. In addition to an estimate of the amount of salts in these soils, it was especially desired to ascertain the amount of their upward movement during dry weather or their downward movement during the rains. But since no two tests can be taken in exactly the same place and since further it is known that the amounts of such salts vary considerably within comparatively short distances in the lateral direction, it became necessary to determine this latter, as an adjunct to the former feature. Such an investigation involves more work than might appear necessary at first sight and the whole series of tests are not yet complete, but it has become abundantly evident that (*i*) the amount of variation laterally is, as was anticipated, comparatively large, and (*ii*) that in these soils the amount of upward movement of salts to the surface during the dry weather is only nominal. This latter feature is quite in accord with expectation; the amount of salts brought to the surface

will depend largely on the amount of water moving upward; if the soil is highly impervious to water, such movements will be very limited; and consequently the amount of salts brought to the surface must likewise be limited. There was hardly any upward movement of water, and accordingly there could be no material concentration of salts at the surface.

The soil being so highly impervious to water, it became of first importance to try to measure this characteristic. By an improvement of a method originally suggested by Mr. Milton Whitney of the United States Department of Agriculture, a mechanical test has been devised, by the aid of which very interesting information has been obtained regarding the rate at which water can move through the Mainpuri as also through other soils. Thus for example, the Usar land in the Mainpuri District which we have been examining, is highly impervious as far down at least as the samples were drawn; the Juhi Usar reserve near Cawnpore is similar to a depth of 5 feet after which it is quite pervious to water; other sterile spots of land have proved to be quite pervious to water, and their sterility must be due to other causes.

In addition to these lines of investigation an exhaustive series of pot-cultures has been commenced at Pusa in order to ascertain whether the defective physical state of the Bhadan (Mainpuri) Usar soil can be remedied or reduced; and if this change were effected, whether the amount of alkali is itself sufficient to cause sterility; also what plants will grow most readily under such adverse conditions.

Finally, in addition to work on the Bhadan soil, the Usar land which has been wholly or partly reclaimed near Aligarh, by the Department and by Mr. Keventer respectively, is being examined in order to ascertain what changes have taken place during the period of years that the work has been in progress.

General Analytical Work.—The number of samples sent for analysis has remained, as in the preceding year,

much smaller than it formerly was. Most of the Provincial Departments are now able to execute all such work for themselves, and assistance in this respect has only been asked for from three provinces. The major part of the remaining samples has been submitted by the officers in charge of the Military Farms, who require opinions on soils and on grasses and other feeding stuffs.

Education.—One student from the Punjab took a short elementary course of Chemistry. One of the assistants of the Agricultural Chemist, United Provinces, is taking a three months' course. In addition, two new assistants on the ordinary establishment have been entertained, and these, as in all such cases, have been largely in the position of students.

Establishment.—The changes involved have been due (*i*) to a junior assistant not being confirmed and another appointed in his place, and (*ii*) to the temporary appointment of a graduate of the Bombay University to act during the absence of other members of the regular establishment. The latter case is of interest, because although this assistant is an M.A. graduate with very good credentials, he was willing to come for a purely temporary acting appointment on Rs. 50 and thereby try to learn something. The other assistant who was appointed during the year, worked purely as a volunteer for about a year in Mr. Hooper's laboratory at the Indian Museum, and has proved an excellent assistant. It is this class of man that deserves most encouragement and likewise generally makes the best public servant; young men who are willing in the first instance to show that they are capable of doing useful work rather than to sit down and do nothing until a highly paid appointment turns up.

Programme of Work for 1910-11.—1. The work on the availability of plant food in soils will be continued, the immediate aim being the more correct ascertainment of the composition of the aqueous solution in the soil. Included in this section of investigation are naturally the amounts of nitrate in soils and soil temperatures.

2. The investigation on soil moisture and water requirements of plants is being continued on lines which have been sufficiently indicated in the memoirs.

3. A joint investigation with Mr. Burt, Deputy Director of Agriculture, United Provinces, is being conducted into the causes of infertility in a tract of land in the Mainpuri District.

4. The effect of soil and manure on the composition of crops is a branch of study which is engaging the attention of a number of investigators and is one on which I have already obtained some information. It will be developed, if possible, at Pusa during the coming year.

5. Two points in relation to the Indian saltpetre manufacture, in respect of which it seems possible that an improvement can be suggested, will be investigated.

6. *Education.*—This requires no special comment; it will be conducted according to the lines laid down.

Publications.—The following papers have been published :—

Memoir No. 8, "The Water Requirements of Crops in India" by Dr. J. Walter Leather.

Memoir No. 9, "The Nature of the Colour of Black Cotton Soil" by Mr. H. E. Annett.

REPORT OF THE IMPERIAL ENTOMOLOGIST, FOR THE YEAR 1909-10.

(H. MAXWELL-LEFROY, M.A., F.E.S., F.Z.S.)

Charge and Establishment.—The Imperial Entomologist held charge of the section during the year. The Supernumerary Entomologist, Mr. C. W. Mason, left the Department on December 19th and Mr. T. Bainbrigge-Fletcher, R.N., F.E.S., joined the Department as Supernumerary Entomologist on the 8th April. The first assistant, Mr. C. S. Misra, who has absent on privilege leave from the 4th May to the end of June, had charge of the students, of the field-work on the Pusa Farm and Botanical area and of the work with lac culture. Apart from the courses of lecturing given by the Impérial Entomologist personally, Mr. Misra has carried out the field and practical instruction of students, which he has done admirably, and also one of the two short courses of instruction given in lac culture. The second assistant, Mr. C. C. Ghosh, has had charge of the insectory and carried out all inquiries conducted there. His work has been of the very greatest utility; he has also been able to prepare a Bengali revision of Indian Insect Pests which has been published. The third assistant, Mr. G. R. Dutt, who was absent on privilege leave from 1st November 1909 to 31st January 1910, has been in charge of economic records, correspondence and collections and has done original work on *Aculeate Hymenoptera.* In spite of his heavy routine work he has found time for both original enquiry and for the compiling for publication of a list of the vernacular names of insects, which is being published. Mr. D. Nowrojee has been in charge of the general collections and has done excellent work in their upkeep and arrangement. The post of Sericulture Assistant, which was filled up by Mr. L. M. Dass, is now held by Mr. R. R. Ghose. The Bengal Entomological Assistant worked in the laboratory for some

months, pending the provision of accommodation at Sabour; the artist staff of the Institute also worked under the direction of the Imperial Entomologist from September to January. The Baroda Entomological Assistant spent a fortnight in Pusa discussing his year's work and the programme for next year.

Training.—The full course of Entomology was given to students from Madras, Central Provinces, Bengal and the United Provinces. It is to be regretted that no students have been sent for the course commencing on June 1st, 1910. A short training, as part of the course in general agriculture was given to a student from the Punjab. The short courses in Eri Silk cultivation have been taken up by 15 students from different parts of India and by boys sent by the United Provinces Agricultural Department. Irregular training in rearing has been given to a number of rearers from Indigo factories, zemindars, etc., who were taking up the industry. The courses in lac have been taken up by 10 students from Lucknow, Hyderabad, Bettiah, Dacca, Cuttack, Jullundur, Rajkot, Jodhpur and Gaya and three *malis* were trained for employment in lac-work in Behar.

Provincial work.—The number of assistants employed in Entomological work in the Provincial Agricultural Departments is now 16+5 for teaching, 11 for field work. This number is wholly insufficient to bring the practical work of Entomology before the agricultural classes, but in the absence of Entomologists in the Provincial Departments to direct their work, the number is not being increased. It is something that applied Entomology forms part of the course of training at five Agricultural Colleges, but it is too much to expect eleven field-assistants to make any progress with showing how crop pests can be checked. As in previous years, the assistance offered in directing and checking the work of these assistants has been utilised by some provinces and the more technical work has been referred to Pusa, leaving the assistants free to do field work entirely. In Madras, the study of the destructive insects

has been continued on the lines laid down in 1906, and very substantial progress has been made; the pests have been carefully studied in almost every district and the preliminary work of collecting information on the spot materially advanced. Good work has been done against the Hairy Caterpillar pest in South Arcot and against the Deccan Grass-hopper which appeared in the Northern Division. In Bombay, very successful work has been done against the Rice Grass-hopper; the Potato-moth and Deccan Grass-hopper are being worked at where they occur and the work should bear fruit this year. Proposals have been made for putting the Entomological work on a better footing and placing it under the general direction of the Imperial Entomologist as in other provinces. In the Central Provinces, the success of the methods tried against Potato-moth has led to their adoption on a larger scale and a careful trial has been made of the trap-crop method of checking boll-worm of cotton on the farms. The cultivation of Eri silk has been experimentally taken up at Multai and Chanda. An investigation into termites in Hoshangabad has been started with the Deputy Director of Agriculture, Northern Circle, and the general pests of the province are being investigated. In Bengal, and Eastern Bengal and Assam, the general investigation of injurious insects has been continued; in the latter, the work against Potato-moth is likely to give good results. In the United Provinces, the work against the Cane Grass-hopper has been the principal item and the general investigation of injurious insects has been continued. The cultivation of Eri silk has been experimentally taken up at Cawnpore. In the Punjab, sericulture and bee-keeping have been experimented with and the general crop pests of the province investigated. In Baroda, good work has been done in inducing cultivators to take an interest in and adopt measures against the Hairy Caterpillar, the boll-worm and the *til* stem-borer, in addition to the usual cases of insect pests reported from various crops.

In general, the provincial work is preliminary and directed to ascertaining what are the pests of the province and how far they are destructive. Only in Madras is the work so far advanced that an accurate statement of the crop-pests can be prepared and a reasonable estimate formed of the possibilities of developing the work. In almost all provinces, progress has been made in coping with crop-pests as they occur in serious outbreaks, but in almost all the work requires systematising on a permanent basis that will conduce to steady progress and eventual thoroughness. Much advance cannot be achieved while the present staff in the provinces is limited to eleven assistants and the direction of the work is in the hands of various officers in the Provincial Departments who have other work to do and who do not want additional staff to look after.

Correspondence.—As in previous years, there has been a large volume of enquiries on all matters connected with insects; the enquiries connected with insects attacking crops have been mainly diverted to the Provincial Departments, but a large mass of miscellaneous enquiries has been received and dealt with. A part of these are from official sources, exclusive of the correspondence with Provincial Agricultural Departments, but a large part also is from the general public; they deal with garden and fruit pests, household pests, insects in grain and timber, insects on domestic animals, insecticides, spraying machines and the identification of insects. The parcels of injurious insects sent in numbered 117. A total of 1,255 enquiries came from official and public sources and at least as many again from planters and others in close touch with the section were answered demi-officially without record. The enquiries with regard to silk numbered over 1,000 and there were many concerning bee-keeping and lac. So far as possible, these are answered by reference to publications, or by the despatch of a leaflet or reprint but they are of such wide range that a very large number must be answered fully and this occupies much time. I hold this work to be of very direct value and I believe every enquiry has been fully and promptly met to the best of our ability.

Research.—Progress has been made with enquiry into the life histories and habits of injurious insects. The more important have been the Palm-weevil, and Rhinoceros beetle, the Army worm, the Rice Swarming Caterpillar, the Deccan Grass-hopper, the Wheat Stem-borer, the Pink Boll-worm, the Indigo Leaf-webber, the Dusky Cotton Bug, Wheat weevil, Rice grain moth. A more careful enquiry into the white ant problem has been commenced partly at Pusa, partly at Hoshangabad in conjunction with the Deputy Director of Agriculture, Northern Circle, Central Provinces. In collaboration with the Imperial Agricultural Chemist, the enquiry was continued into the relation between weevil and the percentage moisture of wheat. The enquiry into the food of birds by Mr. C. W. Mason was brought to a conclusion and the results will be published. The new insecticide was thoroughly tested and is now on sale. An increasing number of patent insecticides have been referred here for trial and report; these have been tested and, with the check afforded by the analysis of the Imperial Agricultural Chemist, reported on as to their value for Indian conditions. Only one has proved to be of any value for this country and, with this exception, the insecticides introduced by this Department are those at present in use; arrangements are made for their sale and we maintain a register of the places where both insecticides and all patterns of spraying machines can be purchased, so that enquirers can be at once referred to the proper places. Until private enterprise finds this business worth taking up, the trial of insecticides and sprayers must be done here and arrangements made for their sale. The question of apiculture is still being considered and further attempts are being made to determine how far bees will thrive and be profitable in the plains.

Sericulture.—The cultivation of Eri silk was continued and all processes to the production of the finished cloth carried on. Three weavers, an average of twelve spinners and cleaners, and about fifteen rearers are constantly

employed and we endeavour to produce every variety of cloth that is likely to be made of this material. The course of training was given to 19 persons, mainly those who wish themselves to take it up as an industry or the employees of those who are commencing the industry. The Pusa Continuous Spinning Machine was perfected and arrangements made for its sale. Assistance was given to the inventor, Mr. R. W. Coryton, of a very ingenious machine for cleaning the cocoons prior to spinning and this machine is now being sold. Every process from rearing the worms to weaving the cloth is being conducted in the silk house, so that visitors can see and quickly understand the whole process. The demand for seed has been very large (in one month $2\frac{1}{2}$ million eggs were sent out) and arrangements were made for an exchange of seed between rearers in different parts of India, this section being the medium for effecting the exchange. Seed was supplied from Pusa to as many persons as possible, but the demand was far in excess of what could be supplied. Many hundreds of persons have given a trial to the industry and while many have, for the present, stopped owing to the absence of any means of disposing of small quantities of cocoons, many are continuing successfully. No attempt was made by this section to popularise or to draw attention to this industry except in Tirhoot, with the sole exception of the publication of an article in the Agricultural Journal of India; yet hundreds of enquiries have come in, from every part of India except Assam, and it is evident that, if there was the organisation to help, advise and buy small lots of cocoons, the industry could be taken up on a very large scale, affording light remunerative work to women and children which they take to readily. In Tirhoot, an attempt was made to induce the Behar Indigo Concerns to serve as buying centres for the hundreds of small lots of cocoons that were being offered but this has failed. Many Tirhoot rearers are still carrying on the industry in order to make and sell cloth but at the commencement all small rearers want to sell cocoons. The industry is establishing

itself, as centres for buying cocoons develop naturally and as the rearers take to making cloth. It is evident that the larger land-owners must take it up first and that the small cultivators cannot do so without some organisation to dispose of their products. It is also necessary at first to be in touch with Pusa or some other centre that can advise and help. The industry is most extensive at present in Tirhoot, Bhagalpur and Patna, the three divisions nearest to Pusa but is being tried also in Malabar, Dharwar, West Coast, Gujarat, Kathiawar, Sind, Patiala, Rohilkhand, Betul, Chanda and Murshidabad. The Salvation Army has also taken it up at Bangalore and elsewhere. Enquiries were made from silk spinning firms in England, France, Switzerland and Japan as to the value of Eri silk cocoons for industrial use there; one Indian silk spinning mill is spinning Eri silk yarn of fine counts, which is being used for weaving in India; but until there is some organisation for collecting and selling large quantities of cocoons, the industrial uses of this material cannot be developed. In this question, we have had the assistance of Mr. Drieberg of the Ceylon Agricultural Society, who is interested in the same problem. Trials are being made at Pusa with hybrids between *Attacus ricini*, the Eri, and *Attacus cynthia*, the wild form; these are not encouraging but may yield a more robust race. The disease of Eri worms which is occasionally a serious and inexplicable factor, is being investigated in collaboration with the Imperial Agricultural Bacteriologist and trials are being made of the various varieties of castor for feeding the worms.

Mulberry silk cultivation was continued mainly to determine how far it can be profitably taken up either to provide raw silk, or to supply cocoons. All available varieties have been collected at Pusa for hybridising. The rearing of the best Italian and French varieties has been very successful; the rearing of the ordinary Bengal varieties has shown that they are not worth cultivating in Behar, and the cultivation of a hybrid between the European univoltine worms and the Bengal multivoltine is

giving good results. The problem of increasing the supply of good cocoons for reeling is of very great importance and there is good reason to believe that very much better cocoons could be produced on a large scale if the industry were developed on the right lines. The experiments of the Bengal Silk Committee and those carried out at Pusa show that success is probable, but that it will take time and organisation to develop the supply and keep rearers on the right lines; failure in inevitable if the present Bengal varieties are cultivated as the silk is almost unsaleable and not worth growing and reeling in new localities. The present experimental work is very satisfactory and the very depressed condition of the silk industry fully justifies the employment of a proper staff to complete and develop these lines of improvement.

Lac.—The cultivation of the lac-insect on *Ber* (*Zizyphus Jujuba*), *Siris* (*Serissa glomeruta*), etc., has been carried on as before and two short courses of training were given to ten students from Bengal, Hyderabad (Deccan), the Punjab, the United Provinces, Kathiawar and Jodhpur, as well as to *malis* from factories in Tirhoot. Lac for seed was supplied to the Bombay and Baroda Departments of Agriculture, to a Court of Ward's Estate in Orissa and arrangements have been completed for forwarding the same to Formosa through the Japanese Consul at Bombay. The most important work of the past year was an enquiry into the races of the lac insect in collaboration with the Forest Department which sent in samples from all parts of India and Burma. The samples are being collected, arranged and forwarded to Mr. E. E. Green, the Government Entomologist, Ceylon, for examination. The number of enquiries regarding lac cultivation in India increased considerably and every assistance was given to those wishing to start it on waste lands in agricultural areas.

Demonstration.—The series of coloured plates of pests has been added to and copies circulated to all Provincial Departments, to the Bombay Natural History Society, the Quetta Museum, the Madras Museum, the Bishop Cotton

School, Simla, the Indian Gardening Association, Calcutta, the Central Agricultural Committee of Madras, the Ceylon Agricultural Society, Colombo, Department of Agriculture, Baroda State, Mycologist and Entomologist, Mysore State and the Director, Educational Section, United Provinces Exhibition, Allahabad. These plates are being utilised in demonstration in all provinces and in vernacular and other publications in Bengal, Eastern Bengal and Assam, Bombay, the United Provinces and the Central Provinces. They are also used in preparing show cases of crop pests for exhibitions, shows, farms, etc. Sample show cases have been prepared and sent out; all Entomological Assistants have been trained in preparing them and it is now only necessary to complete the series of plates to cover all crop-pests, beneficial insects and such useful insects as silk, lac and bees. Trials are being made of coloured lantern slides of these plates to enable lectures to be given at agricultural shows, etc. Assistance was given in preparing show-cases and exhibits for the agricultural section of the Lahore Exhibition and a working exhibit of Eri and mulberry silk was sent to the Muzafferpur Exhibition.

Insect Survey.—Less time has been given to the work with the general collection, only new accessions being placed and arranged. The students' working collection has been very much added to. Collections have been sent away for the use of authors of coming volumes of the Fauna of India. These include the *Collembola, Orthoptera, Mallophaga, Braconidæ* and *Ichneumonidæ, Neuroptera, Odonata, Dynastidæ, Rutelidæ* and *Cetoniidæ, Cantharidæ, Curculionidæ, Microlepidoptera, Thysanoptera, Rhynchota, Heteroptera* and *Homoptera.* Further collections were identified and arranged for the Bombay Natural History Society, and specimens were identified for private collectors, for the Madras Museum and the Quetta Museum. Similar collections were made up and identified for Provincial Agricultural Colleges and a large mass of identified material is available for distribution.

Miscellaneous.—The Imperial Entomologist is President of the Entomological Section of the Bombay Natural History Society and lectured to the Society in September. All entomological enquiries sent to the Society are referred to him and insect specimens sent in for identification are referred to Pusa. The Imperial Entomologist also acted as Chairman of the Indian Sub-Committee of the International Congress of Entomology to be held at Brussels in 1910. An exhibit illustrating the work of the section was sent to the delegate for India, Mr. F. M. Howlett, Second Imperial Entomologist. Assistance has been given to the Government of Japan in regard to Eri silk and lac and the latter insect is being introduced into Formosa. The improvements made in the treatment of Eri silk have been communicated to the Ceylon Agricultural Society. Parasitised cotton boll-worms were sent to Ceylon and Egypt to introduce the parasite; live Eri cocoons were sent to Ceylon, China and Formosa, and live tussur cocoons to Egypt; Eri cocoons were also sent to England and France, the former in order to be crossed with *A. cynthia*, to improve the race. In exchange, *cynthia* cocoons were received at Pusa for the same purpose.

Programme of work for 1910-11.—The work of the past in studying and advising on crop-pests will be continued. Assistance will be given, when desired, in directing the work of provincial assistants, in coping with outbreaks of crop pests and in organising exhibitions for agricultural shows. Assistance is being given in the entomological exhibits at the Allahabad Exhibition. The issue of coloured plates is being continued and coloured lantern slides for lectures will be issued for trial. Further work on apiculture will be done and the short courses of instruction in Eri silk, mulberry silk and lac continued. The progress of the Eri silk industry will be assisted specially with a view to finding foreign markets and to the using of the material for products required in India. The question

of growing better races of mulberry silk for supply to the Bengal filatures will be further tested and the general question of improving the silk industry investigated.

Publications.—The edition of Indian Insect Pests is exhausted and the progress for the last four years makes a new edition necessary. A revision up to June 1909, has been translated into Bengali by the second assistant, Mr. C. C. Ghosh, and published in Calcutta. Applications for permission to publish other translations have been referred to the respective Provincial Departments as a revision of the text is required and the staff at Pusa cannot translate into all vernaculars. "Indian Insect Life" has been issued and is now available for all students and workers in Entomology. A list of other publications is attached. This is smaller than it might be, but the time has not been available for preparing more and the issue of these has entailed much work that should not fall on the staff of this section.

PUBLICATIONS.

Indian Insect Life. (Text-Book.) September, 1909.
Fasaler Poka. (Text-Book.) September, 1910.
Lac as an Agricultural Product. (Agri. Journ. Ind.) July, 1909.
A New Insecticide. (Agri. Journ. Ind.) April, 1910.
Weevil in Wheat. (Indian Trade Journal.) November 18, 1909.
Fauna of Tirhoot I. Rhynchota. (Ind. Mus. Records.) December, 1909.
Storage of Potatoes. (Agri. Journ. Ind.) January, 1910.
Thrips in Tea in Darjeeling. (Agri. Journ. Ind.) July, 1909.
Instructions for rearing Eri Silk. (Leaflet in English, Hindi, Bengali.) January, 1910.
Eri Seed Exchange. (Leaflet.) January, 1910.
Life-Histories of Coleoptera. (Memoir.) January, 1910.
Vernacular Names of Insects. (Bulletin in press.)
Tukra Disease of Mulberry. (Agri. Journ. Ind. and Bengal Agricultural Journal.) April, 1910.
Three Journal Reviews.

REPORT OF THE IMPERIAL MYCOLOGIST FOR THE YEAR 1909-10.

(E. J. BUTLER, M.B., F.L.S.)

Charge and Establishment.—Mr. W. McRae, M.A., B.Sc., Supernumerary Mycologist, held charge of the Section until December 27th, 1909, when I returned from leave. Mr. McRae joined his new appointment as Mycologist to the Government of Madras immediately after; his loss was much felt, but he has taken charge of mycological work in a province which is second to none in India in the number and magnitude of its fungus diseases of plants. His successor, Mr. F. J. F. Shaw, B.Sc., A.R.C.S., joined his appointment on January 28th, 1910. The vacant post of first assistant was filled by Mr. J. F. Dastur, B.Sc., on May 14th, 1910. Mr. J. H. Mitter, second assistant, was appointed Assistant Professor of Mycology in the Punjab Agricultural College, Lyallpur, from June 1st, 1910. The remaining members of the laboratory staff have each received promotion as a consequence. All have done good work. Messrs. J. H. Mitter and S. N. Mitra have given material assistance in the training of students and in general laboratory work; the latter, Mr. A. Hafiz Khan and Munshi Inayat Khan in field work and on tour; while Mr. Hafiz Khan, by his keenness and capacity for independent research is proving a valuable assistant. In Munshi Inayat Khan we have one of the most useful types of native botanical assistants; without any English education, he has yet an almost phenomenal knowledge of indigenous plants gathered during long service under Mr. Duthie in the Saharanpur Herbarium and as a collector in all parts of Northern India. He is in charge of the herbarium and collections, which are well kept up. The Bengal Mycological Assistant worked in the laboratory pending the provision of accommodation for him at Bhagalpur, until April 14th, 1910.

2. *Training.*—Nine students in all received instruction during the year. Of these two were second year students undergoing the full course. Their training ended on March 31st, 1910. Three were members of the Punjab Agricultural Department and received elementary instruction as part of a general agricultural course. As the Provincial Colleges are now in a position to teach elementary mycology, it is not expected that any more students of this class will be received. The student under training as Mycological Collector for Eastern Bengal finished his course on March 2nd, 1910. A Forest Ranger was deputed from the Punjab for an elementary training in the diseases of fruit and forest trees, and a private student from Oudh received a short course in fruit and vegetable diseases. Only one student (private) joined for the full two years' course at the beginning of the new term, June 1st, 1910, and he has since abandoned it. The three senior students took up about half my time in January, February, March and June, chiefly in the preparation of the lectures.

3. *Accommodation.*—The capacity of the general laboratory for students and assistants has been taxed at times, especially when several have been simultaneously engaged in original work. For a time eleven were working in the one room, which is too many for the space available. A portion of the clerk's room has been fitted to relieve pressure in the laboratory. The chief requirement at present is a small outside room with enclosure attached for inoculation and pot-culture experiments. The herbarium has been largely added to (364 named sheets), and has ample space for subsequent expansion in a room on the 1st floor. Improvements were made in the sterilising and culture rooms.

4. *Aid to Provincial Departments.*—Collections of named fungi, chiefly parasitic, have been furnished to the Madras, Punjab, Bengal and Eastern Bengal and Assam Departments. Duplicate collections made in Bombay and Burma have been identified as far as possible and the determinations forwarded to these Departments. This work

will be continued so as to provide a nucleus for a mycological herbarium in every provincial college. The detailed syllabus for an elementary course of lectures and practical work in Indian Mycology, drawn up last year, is being utilised as basis for the mycological instruction in several colleges. The recommendation of the Board of Agriculture of 1908, that each province should have at least an Assistant Professor of Mycology and one other assistant is being worked up to fairly well. Besides Madras, which has now its own Mycologist, Mr. McRae, with one scientific assistant, Bengal, Bombay and the Punjab have each an Assistant Professor of Mycology attached to its college, the two former having a Mycological Assistant as well. The Central Provinces College has a Mycological Assistant, and Eastern Bengal a Mycological Collector. All these, except the Bombay Assistant Professor, have been trained at Pusa.

5. *Research Work. Blister Blight of Tea.*—This was the most important new work taken up during the year. The disease, which has been known for years in North-East Assam appeared for the first time in Darjeeling in 1908. In 1909 it extended, and the Darjeeling Planters' Association asked for the assistance of Pusa. Mr. McRae spent a considerable time in a local investigation of the blight. The life-history of the fungus (*Exobasidium vexans* Massee), before imperfectly known, was fully worked out and an extensive series of experiments on remedial measures undertaken. As a result of these, definite recommendations were made for the cold weather of 1909-10 and general measures for the control of the blight advocated. The results of the work were communicated in two reports to the Darjeeling Planters' Association, by which body they were printed for circulation to the planters concerned. In the present season, the blight is continuing to spread and already threatens the Dooars and Terai. Its progress will be watched with great anxiety by all interested in tea. It is feared that the climatic conditions prevalent in these districts will induce

greater virulence than anything known in Assam, but this will not be known with certainty until the close of the present or perhaps another season. A popular account of the disease is given in the Agricultural Journal of India for April, 1910, and a fuller report is in the press as a bulletin.

Other Tea Diseases.—Mr. Shaw is engaged in the study of the obscure canker of tea, which has long been known but the cause of which is still not ascertained. A disease of tea seed was investigated, but the cause was not definitely discovered.

Palm Disease.—The campaign having as its object to prevent the spread of the bud-rot of palms on the East Coast and to stamp it out within the affected area was prosecuted with energy by the executive officer in charge, Mr. W. K. Green, Special Deputy Collector, Godavari District. I accompanied Mr. McRae, to whom the scientific control has now passed, and Mr. Green on a short tour of inspection early in the present year. Recommendations for continuing the work have been made, especially for its energetic prosecution in Kistna District, where it has been neglected in spite of repeated warnings. Mr. Green was put in charge of work in Kistna as well as in Godavari from January last and this led to better work. A full account of the disease and measures taken to check it is in the press as a memoir. Mr. McRae enquired into a disease of palms at Bapatla in December but found it was not fungal. The coconut root disease in Travancore mentioned in last report is engaging the attention of the newly started Agricultural Department of that State, and measures have been taken on the lines suggested to prevent its spread. The cultivators of neighbouring districts have been warned through vernacular pamphlets of the danger of introducing certain coconut produce from Travancore.

Sugarcane Diseases.—The work in connection with these has not yet reached the stage of publication. Field experiments on the methods of infection of red rot having developed unexpected difficulties, it will probably be neces-

sary to continue in pot culture. Nothing has occurred to shake the opinion advocated by this section that it is primarily a disease conveyed in the sets and it is encouraging to report that scarcely a trace of it could be found at Samalkota Farm in the last crop. Similarly at Pusa there is ordinarily little, except near where the inoculation experiments are in progress. These results are believed to be due almost entirely to the methods of set selection recommended in 1906. There is, however, a good deal still to be elucidated. The life history of three undescribed sugarcane parasites has been in great part worked out. One causes a root disease in certain varieties of cane at Samalkota; its study has been carried out chiefly by Mr. Hafiz Khan, who has also investigated a leaf disease at Pusa. The third is prevalent in Behar. Work on sugarcane smut was continued.

Wilt-Diseases.—The results of the work of several years on the wilt disease of pigeon pea were issued as a memoir early in 1910. No opportunity arose for the study of other field crop wilts still awaiting investigation. In November, Mr. McRae visited the Wynaad at the request of the United Planters' Association of Southern India to investigate the pepper-vine wilt. He was accompanied by Mr. R. Anstead, Planting Expert to the Association, in conjunction with whom a scheme of experiments in the treatment of the disease was drawn up. As the cause, and indeed the whole history of this disease are still obscure, little advice of real value to pepper planters can be given as yet.

Ginger rot.—The investigation of this disease, caused by *Pythium gracile*, was continued by Mr. McRae, who visited Rangpur, Eastern Bengal, twice during the season. It is the principal trouble connected with ginger growing in this district and in Gujarat. It is hoped to publish an illustrated account shortly, with suggestions for treatment. Experiments so far appear to indicate that it is possible to check it by careful seed selection and rotation.

Fruit Diseases.—The survey of diseases of temperate fruit trees in India, was continued, chiefly from material

collected in Kashmir in 1908. Wither tip of citrus trees occurred at Pusa and experimental treatment was carried out. Other citrus diseases are under study at Pusa. A papaya disease which has killed a number of trees at Pusa was studied by one of the students and Mr. Mitra, but the work is not yet ready for publication.

Forest Tree Diseases.—As usual a number of these were investigated for the Forest Department and other persons. The chief of interest was *Fomes lucidus*, a probable parasite of several valuable trees including *Shisham* (*Dalbergia sissoo*) and Areca palm. An illustrated note on this was written for the "Indian Forester." The well-known parasite of the Himalayan blue pine, *Trametes Pini*, was discovered for the first time attacking deodar near Simla. Mr. Hafiz has been occupied in an attempt to determine the manner of spread of this fungus from specimens forwarded by the Imperial Forest Botanist.

Other Plant Diseases.—Two diseases caused by species of *Phytophthora* were investigated by the senior students under supervision. The life history of *Phytophthora Colocasiæ* was worked out. The other, which attacks seedling castor, appears to be undescribed previously. The work will be published after some further necessary study. Several cases of disease of important crops caused by the root-rot fungus, *Rhizoctonia*, were studied. Jute, potato, linseed, tomato, brinjal, castor and some pulses are amongst the plants attacked by this fungus, the existence of which in India has only recently been ascertained. An illustrated account of the leaf spot of turmeric, due to a new species of *Taphrina*, has been prepared for publication. Specimens of rice bunt, caused by *Tilletia horrida*, were received from Germany, on rice said to be of Indian origin. As this disease has only been reported from Japan and the Southern States an enquiry is being made as to its possible occurrence in India, especially Burma. The disease of

Para rubber trees due to *Corticium javanicum* was reported from estates in South India. Other rubber tree diseases were received from Burma. The examination of and reporting on these and many other diseases of crops and economic trees formed a large part of the routine work of the section.

Systematic work.—This was prosecuted as time allowed but the progress made was small owing to pressure of other work. As the demands from the Provincial Colleges for correct determination of their parasitic and other fungi are increasing, it is hoped to give more time to the subject than has been possible recently.

Miscellaneous.—Eight show-cases illustrating characteristic fungus diseases of plants were prepared for the Lahore Exhibition and six for the Bengal Department to exhibit at shows. Suggestions were made for regulations for the control of the importation into India of plants or parts of plants likely to introduce dangerous fungus diseases. Mr. Shaw assisted the Imperial Bacteriologist in the laboratory work in connection with Eri silk-worm disease.

Programme of work for 1910-11.—It is proposed to resume the work on soil fungi if time allows.

The work on the wilt diseases of crops, especially of indigo and cowpea and, if opportunity occurs, of cotton, gram and sesamum, will be continued.

The investigation of sugarcane diseases is being continued and the new results will be published.

It is hoped to obtain more information regarding the occurrence of *Rhizoctonia* on the crops mentioned above and to investigate its life history and treatment.

The study of the diseases of papaya, castor, colocasia and rice mentioned above, of tea canker and of heart-rot of blue pine will be continued.

The study of some anthracnoses of pulse crops will be continued.

It is hoped to work through another portion of the collections and to publish the determinations.

The training of students in Mycology will be continued. No student is taking the full course this session.

PUBLICATIONS.

Fomes lucidus (Leys) Fr., a suspected parasite. E. J. Butler. Indian Forester, September 1909.

The Wilt disease of Pigeon Pea and the Parasitism of Neocosmospora vasinfecta Smith. E. J. Butler. Memoirs of the Department of Agriculture in India, Vol. II, No. 9, January 1910.

The Outbreak of Blister-blight on Tea in the Darjeeling District in 1908-09. W. McRae. Agricultural Journal of India, Vol. V, Part 2, April 1910.

REPORT OF THE IMPERIAL AGRICULTURAL BACTERIOLOGIST FOR THE YEAR 1909-10.

(C. M. HUTCHINSON, B.A.)

The principal work of the Section for six months during which I have been in charge has been directed towards a general examination of the bacteria in the soils of Pusa. The scheme of work has resolved itself into :—

(1) Observation of occurrence and activity of bacteria at varying depths in the soil—

(*a*) with regard to varying species;

(*b*) with regard to their relations to soil chemistry.

(*a*) Determination of the species occurring in soils naturally involves a large amount of culture work extending over a long period of time, and has only been undertaken in consideration of the absence of information on this point so far as Indian soils are concerned. It is hoped that further experience gained in this way will enable a distinction to be drawn between those species whose widespread occurrence and activity makes them of importance from an agricultural standpoint, and others whose restricted development renders it unnecessary to study their characters from this point of view.

In addition to cultures made from samples obtained by boring, observations have been carried on periodically as to the bacterial content of soils in the Botanical Section especially those under experimental treatment by "weathering"; it is hoped that some light may be thrown upon the causes underlying the differences resulting from this method of dealing with soils.

The ordinary cultural methods of differentiation have been somewhat restricted by the impossibility of using gelatine owing to the high temperatures at Pusa in the

months of March, April, May and June. It is hoped that it may be found possible in the future to establish a hill station laboratory, where this difficulty may be eliminated during the hot season.

(*b*) The distribution and activity of the nitrifying organisms has been studied closely in samples taken from various depths and localities. The value of the information acquired has been considerably discounted by the contamination of some of the cultures owing to the absence of a suitable room for carrying out inoculations and withdrawing samples. During the dry hot months the air is charged with dust particles carrying innumerable bacteria and the periodical withdrawal of samples from the culture flasks is attended with great risk of infection of the latter, when conducted in the open laboratory. A suitable room, capable of being isolated from the general laboratory and kept free from dust and currents of air, was selected early in February, and arrangements are being made to have it converted for this purpose.

Active nitrification has been observed in borings from the plots attached to the pot culture house down to a depth of 24 inches, the greatest amount taking place in the second six inches. The samples were taken in February, when the dryness of the surface soil would naturally depress the general level of bacterial activity.

It is of interest to observe that salts of magnesia have been found to inhibit nitrification entirely in Pusa soils when the latter are seeded into liquid media. This effect is being further investigated with a view to determining its underlying causes. Samples have been obtained from borings to a depth of nine feet and it has been of interest to discover the relatively enormous numbers of bacteria present in the Pusa soils and their occurrence in the samples taken from the lowest depth, it having been found necessary to use dilutions of one in one hundred thousand in order to obtain a workable number of colonies in plating.

Some work has been done on nitrogen fixation in certain soil samples, but only of a tentative nature, fuller consideration of the subject being postponed until such time as my assistants have acquired more knowledge of bacteriological methods. It is proposed to make exhaustive enquiries into the distribution and characters of nitrogen fixing organisms in Indian soils, as it seems probable that this source of nitrogen is of prime importance and may even afford possibilities of control in actual practice, either by actually supplying such organisms to soils in which they are deficient, or, as the more hopeful means, by adopting methods of agricultural practice which would allow of the fullest development of those already naturally present.

Disease of Eri Silk Worms.—At the request of the Imperial Entomologist, a lengthy enquiry into the causes producing a very high mortality amongst Eri Worms has been undertaken, and is still in progress. The disease, the symptoms of which resemble those appearing in Flacherie of the Mulberry Worm, is associated with the presence of a bacterium, pure cultures of which have been made from the gut of diseased worms; attempts to establish the pathogenicity of this bacterium for Eri Worms, by feeding with leaf sprinkled with water shaken up with the cultures have so far failed to give decisive results. From enquiries made in Assam in the course of a tour undertaken with the object of enquiring into this matter, it appears that the disease, although known to native sericulturists, is considered due to defective feeding and management and not to be of the nature of an epidemic. Further experiments will be carried out with a view to determining the effect of varying food materials and feeding methods. Numerous sections of the intestine of normal and diseased worms were made by Mr. Shaw of the Mycological Section, showing the defective digestion characteristic of the disease and the development of the bacteria in the gut. These illustrate clearly the differences in the digestive processes incident to the disease, but it is not certain whether the increased number of bacteria is a cause or an effect of the

abnormal condition, although it appears probable that they contribute largely to the final result.

In connection with this enquiry, cultures were made from eggs of the Eri moth, which in many cases were found infected with a bacterium, differing however in cultural and morphological characters from that found in the gut of the diseased worms. Eggs of the same brood hatched out successfully forming healthy worms, but the next generation became diseased and died off. Further enquiries will be made as to the transmission of disease by inheritance.

The efficacy of Trope-Ratine, a patent vermin killer specially prepared for use in India, was tested at the instance of the Director. Rats fed on this material appeared to benefit from its nourishing qualities but were otherwise unaffected. One mouse, however, succumbed and was subsequently eaten by the rats without ill effects to the latter. It appears probable that the material had been kept too long since its preparation to retain its original virulence, a period of nearly five months having elapsed since its despatch from England.

I took over charge of the Section on 27th December 1909. As no previous establishment had been formed a Third Assistant was appointed, Mr. C. S. Rama Aiyer, previously acting as an assistant in the Chemical Section here. Subsequently in May, Mr. N. V. Joshi, who then held the post of an assistant under the Agricultural Chemist to the Government of Bombay, at Poona, was appointed as first assistant. The post of a second assistant is still vacant. Owing to the impossibility of obtaining qualified bacteriologists at the small rate of pay provided for this Section, I have been obliged to appoint men without any bacteriological qualifications; this necessarily results in most of my time being spent in training my assistants in the necessary technique, and this will of course retard the progress of the various investigations which, I hope, to carry out. Owing to the very special

nature of bacteriological research, a lengthy course of training and wide experience of the methods in use is necessary before any student can hope to do research work of any value on this subject, and I wish to record my emphatic opinion that in view of the admitted fact that adequate knowledge of the bearing of the biological factor on soil fertility is of prime importance in agricultural practice, it is highly expedient that the work of this Section should be facilitated by the addition of a trained Supernumerary to my staff.

Programme of work for 1910-11.—In addition to the work indicated in the following programme already submitted to the Board in February, certain special subjects for investigation will be taken up as occasion arises and opportunity permits. Of these, the further work necessary on the disease of Eri Silk Worms, and any special work on bacterial diseases of plants, will be leading features.

The Biological aspects of tillage in Indian soils.—This will involve investigations extending over a prolonged period, the basis of which would include a general investigation of the bacterial content of Indian soils.

Concurrently with this general investigation special observations will be made with the intention of determining the biological factors underlying certain problems of agricultural interest such as those connected with the custom of embanking wheat lands. They will also include enquiries into :—

(1) The biological aspects of the availability of plant food in soils.

(2) The biological factors concerned in the decomposition of organic matter in Indian cultivated soils.

(3) Biological aspects of :—

(*a*) Green manuring in India.

(*b*) " Weathering " of soils.

(*c*) Effect of ploughing land when too wet, before sowing.

No. (1) will be carried out in collaboration with the Imperial Agricultural Chemist, No. (2) in collaboration with the Imperial Mycologist, and No. (3) in collaboration with the Imperial Economic Botanist.

REPORT OF THE IMPERIAL COTTON SPECIALIST FOR THE YEAR 1909-10.

(G. A. GAMMIE, F.L.S.)

I held charge of the appointment throughout the year. From the 6th to the 9th July 1909, I visited Bombay to discuss work in cotton with some of the principal merchants there. From the 26th to the 28th July I visited Jalgaon to advise regarding the cotton section of the Exhibition to be held in the following January; from the 13th October to the 11th November I visited the Garo Hills, Dacca and Chittagong in Eastern Bengal at the invitation of the Agricultural Department; from the 12th to the 27th November I visited various parts of Bengal in company with the Economic Botanist with whom I discussed the future line of work to be conducted in his province. From the 28th November to the 7th December I was in the Central Provinces arranging matters with the Deputy Director of the Southern Division, from the 14th to the 16th December I met the Deputy Director of the Northern Division at Harda and settled with him the details of future trials in his division, from the 18th January to the 23rd January I visited the Farms of the Southern Maratha Country with Mr. Clouston, Deputy Director of Agriculture, Southern Division, Central Provinces, and Mr. Main, Deputy Director of Agriculture, Bombay. From the 26th January to the 5th February I attended the Jalgaon Exhibition where I took charge of the Cotton Section and discussed matters of interest with merchants and cultivators of Khandesh and Berar. From the 17th to the 21st March I visited places on the hill tracts of Belgaum and Dharwar to ascertain the progress of experiments with *buri* cotton. From the 1st to the 5th May I visited Cawnpur at the invitation of the Economic Botanist to advise regarding his experiments. From the 21st June till the end of the month I

toured with the Deputy Director of Agriculture, Bombay, and discussed minutely with him the results of the trials achieved so far by him.

The following are the notes and reports drawn up by me and they embody the information and impressions gathered on the more important aspects of the cultivation of cotton in the provinces :—

Eastern Bengal and Assam.—In company with Mr. Hector, I have completed an enquiry on the cultivation of cotton in the Garo Hills and Chittagong Hill tracts.

In a note on the subject of cotton by Mr. Hart based on his visit to the Chittagong Ginning Mill, he states that " one of the important problems to tackle is to find out (1) whether that of the Garo Hills is a better *jat* than those grown in the Chittagong Hill tracts or (2) whether the difference is due simply to soil and climate."

Probably all the hill cottons belong to *Gossypium neglectum*, var. *Assamica* of Watt in his " Wild and Cultivated Cotton Plants of the World." The most perfect form found in the Garo Hills is a very large bolled plant but a smaller bolled variety is also found. This Garo Hill cotton is pronounced to be the finest grown in the Hill tracts of the Provinces and its staple often reaches from $\frac{3}{4}$ to 1 inch in length. It must be remembered, however, that it is not used in commerce as cotton but as a substitute or adulterant in wool manufacture and that any attempt to improve it from the point of view of the cotton merchant would result in a serious diminution of price as it would then at once come into competition with the inferior grades of cotton which are so largely produced in some parts of India more accessible to the markets.

In the Chittagong Hill tracts and probably in all the other tracts also, a small bolled form is common. The cotton is shorter in staple than that of the Garo Hills and the percentage of cotton to seed is lower. We were informed by the American Missionaries at Tura who take special interest in cotton cultivation that they had been

unable to rear tree cottons. Taking into consideration the heavy rainfall of the Hill tracts, it is obvious that any experiment towards the introduction of ordinary commercial cottons, which seldom tolerate a rainfall of more than 40 inches, is doomed to failure. They have, however, promised to undertake trials with *buri* and Cambodia which are known to withstand heavy rainfall but even in the remote event of their success, it is difficult to imagine that they would thrive under the peculiar system of *Jhum** cultivation which, from all accounts, gives the indigenous plant exactly the conditions it requires. Mr. Hutchinson, the Superintendent of the Chittagong Hill Tracts, informed me that he made a trial with *buri* cotton. The plants made a good growth and looked so well during the vegetative period that the cultivators were favourably impressed with its possibilities, but finally it refused to form bolls and thus was absolutely unproductive.

There is, of course, no doubt that the Garo Hill cotton is the best and the proprietor of the Ginning Factory at Chittagong classified the cottons according to value as follows :—

(1) *Garo Hill or Chilmari;* (2) *Jala* from Lamding, (3) *Bong* from Chittagong, (4) *Cachari* and *Comilla.* The difference in price to the cultivators between the best and the worst varieties may be only Re.1 per maund, while at the same time, it is understood that this may mean at least Rs. 4 or Rs. 5 to the merchant.

So far as I can gather, and I presume this to be correct, there are scarcely any appreciable differences of climate in these tracts and the rainfall is very heavy. The superiority of the Garo Hill cotton may be due to the great proportion of lime in the soil as calcareous rocks abound. I would suggest that samples of soils be procured from *Jhums** in the Garo Hills and Chittagong Hill Tracts for the determination of this point by the Agricultural Chemist. At the same time, it would be interesting if he could dis-

* Temporary fields made in a forest by cutting down jungle and burning it over the land.

cover the reason why *Jhums* require such a long period of rest. The mixture of crops in a *Jhum* seems to be regulated in such a way that each comes to maturity successively. Cotton is the last to do so and when ripening, it covers the ground at about the correct density for the production of a full crop. I learn from Mr. Hutchinson that he has tried the cultivation of Garo Hill cotton on the initiative of Messrs. Ralli Brothers and, in his opinion, the resulting cotton was in no way different from that of the prevailing variety of his district. Mr. K. C. Dewan, Sub-Deputy Collector, says the average acre outturn in Chittagong is 400 to 480 lbs. of seed cotton, while the average of 9 cropping experiments in the Garo Hills gives 500 lbs. of seed cotton and 254 lbs. of clean cotton. This is a percentage of cotton to seed of nearly 51. Taking the Chittagong cotton to have an average of 40 (and it is certainly not more) the acre outturn of clean cotton would only average 176 lbs., leaving an excess in favour of Garo Hill cotton of 78 lbs. per acre. From the bazar rates that I have been able to obtain, it appears that all the seed cotton is paid for at about the same rates while it is obvious that from its superior quality and higher ginning percentage, the buyer should give a higher price for Garo Hill cotton. At present, I understand that the cotton trade is in the hands of native merchants who make advances to the cutivators on the security of the crop and that the method of disposing of the produce finally to Europe is doubtful.

In conclusion, I would recommend (1) that no alteration should be made in the type of cotton grown as the experience of generations has taught it to be the only sort capable of growing under the excessive rainfall and the primitive agriculture of the Hill Tracts; (2) that any selection to be done should be undertaken with the view of increasing the length of the staple, and the percentage of cotton to seed, but not, however, with the idea of modifying the special characteristics of the product; (3) that the Garo Hill cotton should be experimentally introduced

into all the tracts so that it can pass under the judgment of local cultivators and the Chittagong cottons should also be tried on a small scale on the Garo Hills to find out whether the change of locality will affect it as regards size of bolls and quantity and quality of produce. All experiments should be placed under the supervision or control of some officer in the Agricultural Department, as work of this nature, when conducted by men with no training in agriculture, is either neglected or fails through lack of the necessary knowledge.

I have discussed cotton matters freely with Mr. Hector, the Economic Botanist, and he is in possession of my views.

Bengal.—There are three species of *Gossypium* cultivated in Bengal, *viz.*, (1) the late variety, G. *intermedium*, *Todaro* (probably), said to be grown most largely as a mixture with *rahar* and other crops in North Behar; (2) *G. neglectum Todaro*, vars. *Bengalensis* and *Kokatia*, comprised in the " early variety " of the agricultural returns and (3) an early maturing form of *G. hirsutum*, called *Buri*. In addition to these, two American tree cottons—Bourbon and Brazilian or chain-seeded are grown sporadically for their cotton which is used for spinning the sacred thread. Throughout Behar, cotton seems never to be grown as a pure field crop, but only as a mixture with *rahar* (*Cajanus indicus*). Probably little of the produce finds its way to the mills as the bulk is used for stuffing quilts and cushions and for other domestic purposes.

As regards projected experiments with a view of popularising cotton cultivation in Bengal only two species appear to hold out any promise of ultimate success. These are the *intermedium* and *hirsutum*.

According to Mr. N. C. Chaudhary who has devoted considerable attention to the subject of cotton cultivation in Bengal, the advantages of *G. intermedium* accrue from its heavy production and fineness of staple and its drawbacks are comprised in its long period of growth and low percentage of cotton to seed. The crop often occupies the ground until June or July, thereby delaying the cultivators

in the preparation of land for the *bhadoi* crop. The percentage of cotton to seed is said to be only about 20 and the outturn of clean cotton per acre from 50 to 150 lbs. The market rate of the cotton varies from Rs. 12 to Rs. 14 per Imperial maund. Mr. Chaudhary says, however, that owing to the shortage of the crop due to excessive rains, the price is this season at least Rs. 5 higher than usual and that Bhuri cotton has lately been bought by the Calcutta mills @ Rs. 30 per maund.

G. intermedium is said to be represented by two forms, one *Deshila* with small bolls and low percentage, the other *Bhogila*, with larger bolls and higher percentage.

By means of the usual methods of selection, it may be possible to improve these varieties (which are eminently suitable for the soil and climate of Bengal) in the points of which they are at present not quite satisfactory. I shall be obliged if Mr. Woodhouse, the Economic Botanist would undertake a trial on the Bhagalpur College Farm and perhaps Mr. Smith, the Deputy Director of Agriculture, might duplicate the experiment in one or more of his farms. The doubt as to whether these cottons will grow or not need not actually exist, the only questions involved are the possibility of increasing the outturn and percentage. At the same time, if samples are supplied to the Calcutta mills, it would be possible to decide whether or not these cottons are really worth growing. Areas of at least half an acre of each should be grown so that the outturns and percentages could be calculated on a fairly large scale and ample material would also be furnished for purposes of selection.

G. hirsutum, Buri, appears to have adapted itself admirably to the natural conditions of the higher lands of Bengal. In Central Provinces, the experience so far gained shows that it withstands a considerably higher rainfall than the local varieties, its outturn and percentage are high and the cotton is valued at the same rate as fine Broach which is accepted as the best of the cottons produced in India. In Bengal, it possesses the valuable charac-

teristic of being a short season variety and being of a low habit of growth it would not compete with a crop such as *rahar*. Its behaviour at the Chaibassa Agricultural Station proves that it thrives even under very unfavourable conditions. I would recommend that careful trials be made with this cotton in the way I have suggested above for *G. intermedium* and in the same localities. It was growing well on the Bhagalpur Farm and I can see no particular objection to its being grown on the Bengal plain. There is another cotton of almost the same characteristics known as Cambodia or Cochin China cotton. This is giving good results both in the Madras and Bombay Presidencies and I have reason to believe that it is still more resistant to heavy rainfall than *Buri*. If early application be made, a supply of seed could probably be obtained from the Deputy Director of Agriculture, Bombay Presidency, Poona.

As regards the two varieties of *G. neglectum*, I consider that they are scarcely worth dealing with, as they are no better than the common low grade cottons which predominate throughout the areas producing the so-called commercial Bengal cottons.

Of the tree cottons, Bourbon may be induced to yield as an annual crop, but it would be advisable not to exploit such an unsatisfactory class of plant.

If the officers of the Bengal Agricultural Department consent to carry out the trials I have suggested, they will not have to undertake a complicated task. They need merely study the possibilities of *G. intermedium* and *G. hirsutum*, the latter preferably in its two forms of *Buri* and *Cambodia*.

Central Provinces.—At the Telinkheri Farm, which I visited in the company of Mr. Clouston, the Deputy Director of Agriculture, the field of selected *Buri* looked extremely well and promised to be highly productive. Mr. Clouston had, with rare judgment, selected a type of plant with short, lower branches and I consider it very fortunate that at such an early period of the cultivation of

this plant he should have had the forethought to pick out what is clearly the best type of plant. I was also pleased to see at Akola that this type had been selected for growth on the seed farms. In Chutia Nagpur, the original Indian home of this variety of cotton, Mr. Woodhouse, the Economic Botanist in Bengal, and myself after examination of the mixed type in the field arrived at the conclusion that this was the type to work on and it was particularly interesting to see at Nagpur and Akola the facility with which this type perpetuates its character of growth. I consider that valuable work is being done in the improvement of cotton in these provinces by the rapid introduction of *Buri*. There is of course the danger of its failure in a season of drought, but in India success can only be attained by incurring a certain amount of risk.

I think that Mr. Evans, the Second Deputy Director of Agriculture, should carefully test the possibilities of this cotton within his charge. From favourable indications afforded by other indigenous varieties already there, I think, his trials will yield him good results. There is, however, at present great variation in the period at which plants ripen their bolls, some plants have completed the process before others have even started, but as all the cotton ripens well within the cold season, this circumstance is perhaps not one of practical importance.

Within the *jari* area, the variety *Malvensis* shows most promise. *Bani* grown at Akola being out of its natural element was actually priced lower than *Malvensis* at Jalgaon. This point is of considerable importance in its way as it goes to prove that *Bani* is the finest cotton in the Central Provinces and Berar only when grown in localities which have been found to be absolutely suitable to it, and care should be taken not to introduce it into tracts where the variety *Malvensis* of *Jari* is indicated as the safer plant to grow. Owing to its requirement for a heavier

rainfall than that prevailing in *Jari* tracts, *Buri* in time may supplant *Bani* or at least it may check the spread of *Jari;* so far as we can see at present, the latter will have no competitor. The only problem in its connection is to ascertain how the outturn of the fine varieties, such as *Malvensis* compares with that of the coarser.

I do not think that any type differing from those we already know will be discovered in this Province. Assuming this to be so, work in cotton should proceed on only a few lines and these may be summarised as follows :—

(1) The introduction of *Buri* to accompany Bani but by no means to oust *Jari.*

(2) The improvement of *Bani* in its percentage and outturn.

(3) The isolation of the different types of *Jari* (which has already been done) and the comparative value of each from the grower's point of view.

I would like to mention here that in my opinion a cotton plot should be at least an acre in extent as the details of outturn are of such vital importance. I find that on small plots too much attention is paid to individual plants and niggling selections are made in trifling differences such as minute variations in the length and quality of lint, etc.

The farmer and trader want to know the outturn and ginning percentage of the crop. The latter will not materially enhance his terms for trifling differences in quality and the former will insist on growing the variety which puts most money in his pocket. The cultivator loses money, however, through his predilection for sending dirty cotton to market. The merchant is often keener on making a good bargain than on paying the farmer higher rates for superior quality.

In addition to what he can secure from Mr. Clouston's long list of selections, I am arranging to supply Mr. Evans

with seeds picked from the best commercial samples obtained from his own division, and I expect he will shortly be in a position to carry through his demonstrations rapidly and soon reach the cultivators. From what I can gather, some of the cottons of his division are already considered good so that his task is simplified to a certain extent.

In conclusion, I wish to record my appreciation of the work being done in cotton by Mr. Clouston and by the projected experiments formulated by Mr. Evans. If they are supported as they deserve, I venture to predict that the Central Provinces will be the first in India to demonstrate that it is possible to obtain a decided improvement in Indian cotton, provided the requisite degree of intelligence and energy are brought to bear on the question and I again repeat that it is futile to work out our problems on flower bed areas.

Berar.—The Province of Berar known in days of yore by the name *Vaidarbha,* has been famous for the cultivation of cotton. It grew some of the best varieties yielding a fine strong fibre. It was the home of the once celebrated *Jari* and *Bani* varieties that afforded a superior sort of material not only to the mill industry in India but also to that in England. At the time of the Civil War between America and England in 1863, when no cotton was received from America, this province supplied the deficiency to a considerable extent.

Area.—Cotton occupies the foremost rank among other agricultural crops, and in comparison to the total cropped area, it is grown much more extensively in this province than in Bombay Presidency. It occupies the second place in India so far as cotton cultivation is concerned, Bombay Presidency being first. Nearly two-thirds of the culturable area is put under cotton, the average area ranging between 28 to 31 lakhs of acres per annum. The average outturn per acre is about 100 pounds clean cotton.

The following six talukas grow the bulk of cotton :—

Akola	740,000 acres.
Amraoti	700,000 ,,
Basim	360,000 ,,
Buldana	420,000 ,,
Ellichpur	350,000 ,,
Yeotmal	480,000 ,,
	3,050,000 ,,

Area under cotton in—

the Central Provinces	1,250,000 acres
Berar	3,000,000 ,,
	4,250,000 ,,

The valley of the Payanghat has an area under cotton to the extent of about 40 per cent. and this valley, it is said, grows the best cotton.

The area under cotton has of late considerably increased in the districts of Basim and Yeotmal as it is found to be more paying than other crops.

The earliest varieties grown in the Province were *Jari* (Chanda *Jari*) and *Bani*. The former was a cold weather variety with fine silky staple about $1\frac{1}{2}$ inches long; the latter was sown at the beginning of the rains and had a fine silky staple about an inch long. The best *Bani* was grown in the Wardha District and it was this variety mixed with a considerable proportion of Chanda *Jari* which was known to the trade as "Hinganghat". In Berar *Bani* (possibly with a mixture of *Jari*) was known as "*Amraotis*" or "*Oomaras*."

Now coarse Jari has come into existence which is sown at the beginning of the rains. This is hardier, coarse and prolific in outturn having a staple of about $\frac{1}{2}$ to $\frac{3}{4}$ inch long.

The two varieties (cold weather *Jari* and *Bani*) yielded a long staple but the outturn of *Bani* was less and was more delicate. Both these varieties had a reputation in the Bombay market until within the last 45 years; but they have been ousted by a variety known as *Kati Bilayati*,

Vilayati, *Houri* or new *Jari*. The evil seems to have been recognised as early as 1867. Dr. Humes then remarked that :—

"The subject of cotton in Berar is one that requires immediate supervision. It has been left in the hands of ignorant Koonbees, who have no thought for the morrow, but grow whatever pays best at the time. The Khandesh variety is being grown largely to the ousting of the other varieties, to the most certain ruin of the Berar cotton trade. At present they get from Vilayati Khandesh an early crop, also a large one, getting three or four pickings instead of two or three as they get from indigenous cotton. They get ₹3 or ₹4 a bale less in price than for the indigenous cotton, but the greater bulk compensates, and much more, for this small loss. But this apparent prosperity will be short-lived, for it is only by mixing this Valayati Khandesh cotton with the indigenous cottons that merchants can get it accepted."

The new *Jari* in recent years has become very popular as its character is sturdy and can stand both excessive rain and partial drought.

Mr. Gaskin, former Director of Agriculture, Central Provinces, says *Jari* is popular for its hardiness and certainty of its heavy yield (1,000 lbs. of seed cotton) giving 330 lbs. lint per acre; the ease with which it is picked up and the fact that it ripens early and so can be placed in the market in October, November.

Bulk for bulk its yield is much larger than that of old *Jari* and *Bani* though the staple is much shorter and less glossy. The old varieties come in the market in January and February whereas the present variety ripens much earlier and enables the cultivator to line his coat with silver in the months of November, December. These circumstances have mostly thrust out the old indigenous varieties of cotton. The change, it is said, came about in this way.

With a view to improve the cultivation in the province, Government introduced the seed known as *Vilayati* or *Houri*, also called *Jari* in some provinces, different from the old Berar *Jari*. The seed was distributed gratis. The trial was so successful and it became so popular that the

old varieties were completely driven out. In connection with the introduction of this variety, Mr. Gaskin observes that by the irony of fate the very cotton which Government endeavoured to eradicate became known as one which they had introduced.

Mr. B. P. Standen, C.I.E., former Director of Agriculture, Central Provinces, states " These are hardy plants which can be cultivated with success in any part of the province when the soil overlies the trap and drains early and the temperature of the cold season is not so low as to kill the plant in December ". According to him, *Jari* (the local *Houri*) has thrust out the old indigenous varieties, *Bani* and old *Jari*, because the former, even in the most unfavourable years, pays better than the latter. The same officer is of opinion that the cultivation of *Bani* on the Ghats south of Berar is due to a spirit of conservatism on the part of the cultivators rather than to any prudential consideration. Not only does *Bani* yield a smaller proportion of lint (25 per cent.) than *Jari*, but it gives also under the most favourable circumstances a small average crop and is more liable to damage from the vicissitudes of the seasons. For these reasons, the old famous varieties of Berar have dwindled and disappeared.

The *Jari* which is cultivated at present is a mixture of the following four varieties mixed to a small extent with Upland Georgian :—

(1) G. N. Rosea. (3) G. N. Vera.
(2) Do. Cutchica. (4) Do. Vera Malvensis, and also *Bani* plants.

Broadly speaking the fibre produced by these varieties increases in value as we go down the list, Rosea producing the shortest staple and priced lowest in the market.

To ascertain the relative value of the outturn of these different types, they were separated out and the seeds obtained were experimented along with Berar *Jari* and *Bani* on the Akola Farm in the year 1907-1908 by Mr. Clouston, the Deputy Director of Agriculture, Central Provinces.

The results are summarised below :—

Name of Variety.	Outturn of seed cotton per acre.	Percentage of lint.	Value of Outturn.
	lbs.		R a. p.
Malvensis	240	33	27 0 0
Verum	182	33	17 8 10
Roseum	258	39	24 14 0
Roseum Cutchica	194	38	18 11 3
Berar Jari	255	38	24 9 6
Bani	151	26	16 15 9

From the above statement, it will be seen that Malvensis having good staple has fetched more but the yield and percentage of lint are less than Roseum and Berar *Jari*.

The following was the valuation of these types last year :—

Roseum	₹54	per candy of	560 lbs.
Cutchica	₹54	do.	do.
Vera	₹54	do.	do.
alvensis	₹63	do.	do.
Bani	₹64	do.	do.

From the valuation, it is quite clear that Malvensis is a very promising variety and compares very favourably with the *Bani*.

During the current year at the Jalgaon Exhibition all these varieties were exhibited by the Agricultural Department of the Central Provinces. They were subjected to examination and the opinion given by the cotton merchants is as below :—

Buri.—Staple long, fine, good cotton. Value per candy of 784 lbs. ₹340.

Roseum.—Staple coarse, short, free from foreign matter. ₹268 per candy.

Verum.—Softer than Roseum ₹272 per candy.

Berar Jari.—Much cleaner than Khandesh. Will fetch a rupee or two more than ordinary Khandesh. Value ₹270 per candy.

Malvensis.—Not strong, but longer and silkier; much cleaner than Varadi. Value ₹295 per candy.

Bani.—Percentage 26, less silky but longer and stronger than Malvensis. ₹285 per candy.

Note:—Rough cottons are always cleaner than soft cottons.

The basis for valuation was Broach at ₹320 per candy.

Selection of seed.—Seed selection is known by the name of Alkabalka. At one time, it was practised extensively. The mode adopted was to select the best opened bolls at the second picking and stack the cotton. This was separately ginned and the seed so obtained was reserved for sowing for the next season.

Now-a-days on account of the introduction of ginning factories any seed is used for sowing and no effort is made towards selection. At the commencement of the gin factories, the machine ginned seeds were looked upon as unsuitable for cultivation, but this prejudice has unfortunately fast died out and the seed for sowing is purchased from Banias who give such seeds as they have at their own price. It is absolutely necessary to revive the old and useful practice of selecting seed and getting it hand-ginned.

Picking.—This is done usually after *Diwali*, by women and children. Payment is made in kind. 1-20th part of the cotton picked is the labour charges for the first picking; for the subsequent pickings, a higher proportion has to be given. These rates depend upon the cheapness of labour. If the labour is scarce, the rates are higher and *vice versâ*.

This practice is still in vogue in some places, but it has been replaced in recent years by cash payment as the cash payment is found to be cheaper. The usual rate of cash payment is annas three per maund of cotton picked. A

labourer is able to pick from a good field two to three maunds of cotton a day, thus earning from 10 to 12 annas a day. A good crop will give 3 pickings.

Outturn.—The average outturn of *Houri* is about 400 lbs. of seed cotton per acre and its average market price is ₹50 per Khandi of 560 lbs. An acre of land under cotton would thus give about ₹35 to a cultivator from which the cost of cultivation which is usually ₹14 may be deducted; the net profit would therefore be about ₹20.

Bombay.—During the year 1909-10 within a radius of 10 miles from Surat, the seed of a cross grown on the Surat Farm was distributed to the cultivators by the Agricultural Department. The produce of this cross, amounting to about 100 *bhars* 100,000 lbs. (960 lbs. make one *bhar* at Surat) has been purchased through the agency of the Bombay Agricultural Department by a gin-owner of Surat who gave ₹7 more per *bhar* for this cotton than the Surat local cotton. The quantity so purchased will gin out about 30,000 lbs. of seed; in addition to this quantity, the Surat Farm also will produce about 5,000 lbs. seed of this cross, the total quantity of seed would, therefore, come to about 35,000 lbs. It is the intention of the Deputy Director of Agriculture, Bombay Presidency, to distribute this quantity to the cultivators of one village only so that this year one village will grow only the cross cotton which will throw sufficient light with regard to the improvement of cotton.

Cordial acknowledgment is due to Messrs. Tata, Sons and Company, Bombay, for their kindness and promptitude in giving valuations and opinions on cotton samples whenever they were submitted to them.

Programme of work for 1910-11.—The work for the next year will consist of a further enquiry into the cottons of Central Provinces, Central India, Gujarat, Kathiawar and Southern Maratha Country.

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REPORT

OF THE

Agricultural Research Institute and College, Pusa

(Including Report of the Imperial Cotton Specialist)

1910-11

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Report of the Agricultural Research Institute and College, Pusa,

(*Including Report of the Imperial Cotton Specialist.*)

1910-11.

REPORT OF THE DIRECTOR, AGRICULTURAL RESEARCH INSTITUTE AND COLLEGE, PUSA, FOR THE YEAR 1910-11.

(E. J. BUTLER, M.B., F.L.S.)

1. *Charge.*—I held charge of the office of Director, Agricultural Research Institute, and Principal of the Agricultural College, Pusa, throughout the year, in addition to my duties of Imperial Mycologist.

2. *Staff and work of the Institute.*—The Institute is organised in seven scientific sections, Agricultural, Chemical, Botanical, Mycological, Entomological, Second Entomological, and Bacteriological, the detailed reports of which are given in the body of this report. For much of the period under review, the superior staff was below strength. Towards its close, three supernumerary officers were absent on deputation or filling leave vacancies in the provinces; the Imperial Entomologist was on long leave; the Assistant Agriculturist's post was vacant; while I occupied the dual posts of Director and Imperial Mycologist. Thus, there were only eight European officers of the Pusa staff actually at work for the Imperial Department, and of these two (the Imperial Economic Botanist and his Personal Assistant) were engaged in Baluchistan, developing the

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fruit industry of that province, in addition to their own duties.

The following summary gives very briefly the organisation of the staff, and the main lines of work of each section during the year.

3. *Agriculture.*—Mr. A. McKerral, Assistant Inspector General of Agriculture, was lent to take charge of the farm up to the 17th November, 1910, when Mr. G. Sherrard, Assistant Agriculturist, took over all except the work in connection with cattle and poultry breeding, which remained under Mr. McKerral until February, 1911. Mr. Sherrard held charge up to the 16th June, 1911, when he was appointed Professor of Agriculture, Bengal Agricultural College, Sabour, and Mr. A. C. Dobbs, Assistant Inspector General of Agriculture, was lent to take charge, pending permanent arrangements. Mr. H. Southern joined the staff as Supernumerary Agriculturist on the 29th November, 1910, but left again on the 13th February, 1911, to officiate for Mr. Sampson, Deputy Director of Agriculture, Southern Circle, Madras, who was about to proceed on leave.

Notwithstanding these frequent changes, and in spite of the fact that since February the farm has been managed by only a single officer, steady progress continues to be recorded. The *rabi* sowings were completed at an earlier date than any previous year, and the harvest was exceptionally good. A yield of 33 maunds of oats per acre was obtained from one field, and a record was established in thrashing, 241 maunds of oats being thrashed in one day with the steam thrasher. The rains set in early in June, 1911, and most of the *kharif* crops were sown before the end of the month and give excellent promise. Against this, the *kharif* of 1910 was marked by extensive floods in Behar, and a large part of the crops on the lower lands was lost owing to a breach in the protective embankment.

The experimental work on the farm suffered from the floods in the monsoon of 1910, one block of the permanent manurial and rotation experiments having been completely

destroyed. The duplicate block on higher land, however, escaped. It is too early to expect results from these experiments. The permanent pasture experiments were abandoned during the year, after full consideration of the results to date. It is evident that the improvement of pasture land will have to be attempted on different lines, and a modified plan of experiment is under consideration. A comprehensive series of manurial experiments with flax was started by the Fibre Expert to the Government of Eastern Bengal and Assam, in collaboration with the Inspector General of Agriculture, but an outbreak of dodder necessitated the destruction by burning of the whole crop. Flax dodder is not indigenous to India, and there is no doubt that every effort should be made to keep it out in future, and to destroy what was introduced in the past. Experiments with jute and paddy were continued, the former according to plans drawn up by the Fibre Expert. As the area under arable cultivation is now more than sufficient to provide fodder and grain for the breeding herd and work cattle, it is hoped to extend experimental work in the near future. A considerable part of the farm is devoted to crops grown for the other sections for observation and experiment.

The farm stock have done well. The Montgomery herd has been increased by natural growth and purchase. Proposals for a dairy were submitted during the year, but sanction has been withheld for the present. There is an undoubted demand for instruction in dairying, and with the large herd of excellent milch cattle now being formed at Pusa, a dairy will ultimately prove an essential part of the equipment of the Institute. The management of the poultry has been in the hands of the Inspector General of Agriculture for the greater part of the year.

I wish to record my appreciation of Mr. Sherrard's work not only on the farm, but in assisting me in the general management of the Estate.

4. *Chemistry.*—Dr. Leather held charge throughout the year. Mr. Annett, on the termination of his acting ap-

pointment as Agricultural Chemist, United Provinces, and on expiry of his privilege leave, resumed charge of his duties as Supernumerary Agricultural Chemist at Pusa on the 11th November, 1910. He has been since appointed to act as Principal of the Agricultural College, Cawnpore, and left Pusa to join this appointment on the 24th June, 1911.

The important investigation on the water requirements of crops in India, to which allusion has been made in previous reports, has advanced a stage, and a second memoir on the subject has been published by Dr. Leather. The principal conclusions arrived at are, that the nature of the soil has no effect on the transpiration ratio, but profoundly influences the rate at which water can move through the soil, and hence the total weight of crop produced. Also, that practically the whole of the water used by a crop is obtained within the root range, some 6 to 7 feet in alluvial soil, the large stores of water below this depth being substantially of no service to the plant.

Drain gauges to test the quantity and composition of the subsoil drainage water from arable land were erected some years ago at Cawnpore and Pusa, and the results of several years' records are now in the press. They yield information of the greatest interest on some of the factors which must always fundamentally influence Indian agriculture, when compared with that of temperate climates. Thus it has been found that the loss of water from bare fallow soil is almost constant year by year in any one place, and is at Pusa nearly double that at Rothamsted in England. At Cawnpore, on the other hand, it is little more than at Rothamsted, and this difference between Pusa and Cawnpore requires to be explained but probably depends on the nature of the soil. The protective influence against evaporation due to the presence of a crop has been approximately determined for different periods of the year. The amount of nitrate present in the drainage water from fallow land is very much greater than at Rothamsted, twice or three times as much, and nitrification occurs with

great vigour after the first heavy rain of the monsoon, but is not active during the dry months.

Dr. Leather has continued his investigation of *usar* land, with special reference to its physical state. He has also, in consultation with the Director of Agriculture, and the Irrigation Department, United Provinces, carried out the first stage of a comprehensive experiment directed to determine once for all whether, as is frequently stated, irrigation leads in certain lands to an increase of alkali.

Mr. Annett is engaged on a general investigation of the Date Palm sugar industry, a very important Indian industry, about which little accurate information is available.

An improved method of refining crude saltpetre was devised by Dr. Leather, and has been described in a Bulletin recently published. More nitrate is obtained than by the ordinary methods in use, the product is of higher quality, less fuel is required, and the process is independent of the weather. Its financial possibilities, however, remain to be demonstrated, and arrangements have been made to test the method on a commercial scale this year.

5. *Botany.*—Mr. Howard resumed charge of this section, on the expiry of privilege leave and deputation in England, on the 29th July, 1910. He was deputed to advise the Kashmir Durbar on hop cultivation from the 1st August to the 27th September, 1910. During his absence Maulvi Abdur Rahman Khan, Second Assistant, held charge of the current duties of the section. Mrs. Howard, who has ably assisted her husband during the past five years, was appointed Personal Assistant for three years from the 1st October, 1910. Mr. E. Holmes Smith, Supernumerary Economic Botanist, was on deputation in the Bombay Presidency throughout the year. He leaves the Department on the expiry of his agreement in October, 1911. Mr. Howard has been placed in charge of a scheme to develop the fruit industry of Baluchistan, in addition to his own duties, for a period of three years from the 1st May, 1911. He will work in Baluchistan for five months, from May to September, each year.

During his absence in England, Mr. Howard carried out some experiments in the production of rust resistant wheats suitable for India, and studied the trade requirements for improved Indian wheat and tobacco. He also enquired into modern methods of hop cultivation and drying and fruit packing, with a view to utilising the information on his return to India.

The possibilities of hop growing in Kashmir are apparent, when it is learnt that with a production per acre of one-fifth of that of Kent, an annual average profit of over £7 per acre has been realised on the Government hop garden, for the last sixteen years. In Mr. Howard's report to the Durbar, the directions are indicated in which improvements are possible, if it is decided to continue the industry on the present lines, and also the steps which are necessary if hop growing in Kashmir is to be placed on modern lines and if Kashmir is to enter the markets of the world as a competitor with California.

Perhaps the most important work on which Pusa is engaged at present is the improvement of Indian wheat. The lines on which this is being carried out have been sufficiently indicated in previous reports of the Botanical Section. The best Pusa wheats produced in 1910 were shown at Mark Lane, and on the Liverpool Corn Exchange, while Mr. Howard was in England, and were acknowledged to be without any superiors on the market at the time. During the past year, the high grain-quality of some of the best of these types has been combined with the high yield of low-quality Indian wheats, as a result of hybridization. The demand, both in India and abroad, for some of the improved wheats produced at Pusa has been far in excess of the supply. It is estimated that over 1,000 acres of the new wheats will be sown in Behar this year. At Raipur and Cawnpore, some of these wheats have proved equally successful, and extended trials have been arranged for at a number of other stations in the wheat-growing tracts of India. Mr. Howard is careful to point out that the full benefit of improved varieties can only be realised if cultiva-

tion is good and moisture is adequate. Disappointment is bound to result, if the influence of these two all-important factors in crop production in India is disregarded.

The improvement of tobacco is being carried on on similar lines to that of wheat. Both in yield and quality of leaf very encouraging results have been obtained.

The botanical study of certain fibres was continued, the isolation of the varieties of *san* (*Crotalaria juncea*) and *patwa* (*Hibiscus cannabinus*), and their improvement by selection and crossing, being the principal work in progress in this direction.

Further work on pollination in important crops of India was carried out, and a Memoir published giving the data for a number of crops.

Towards the end of the year, the lines of work on the improvement of the fruit industry of Baluchistan were developed, and the site of a new Experimental Station for the purpose selected near Quetta.

6. *Mycology.*—I held charge of this section during the year, in addition to the office of Director. Mr. Shaw continued to hold the post of Supernumerary Mycologist.

Much time was given to systematic work, as it was found that progress in Indian economic mycology was greatly hampered by the difficulty in determining the identity of the fungi of the country. All the specimens of one of the larger groups, the Ascomycetes, were worked through and annotated lists were published after the close of the year under review.

The charge of the campaign against palm disease in Godavari and Kistna Districts was taken over by the Madras Mycologist in 1910. It is being continued on the same general lines as before. A full account of the disease, and of the campaign against it carried on since 1907, was written by me and published as a Memoir in September, 1910. The conclusions arrived at are that the operations have been entirely successful in limiting the disease in Godavari to the area previously infected: the work in Kistna was started later, but the progress is encouraging

in this district also. The effect of the work in reducing the severity of the disease within the infected tract was not easy to estimate when the report was written, but with the further records since available it appears that a distinct decrease in the mortality is noticeable at the present time. If the disease can be effectively confined to the existing limits, the outlay incurred will be amply justified, and there is every reason to hope that the continuation of the work will lead to its being gradually stamped out altogether.

The need for a mycologist to work specially on the diseases of the tea plant has become increasingly apparent, and the Indian Tea Association have decided to add an appointment of this nature to their Scientific Department. Meanwhile, Pusa gives such assistance as is possible. Mr. McRae's Bulletin on blister-blight in Darjeeling, published at the beginning of the year, indicates the lines on which the control of this dangerous blight should be attempted. Many planters are experimenting on these lines, but the disease is firmly established and still spreading; unless a cheap and effective method of lessening its ravages can be worked out, there is every reason to fear that the result will be a permanent and considerable reduction of the Darjeeling tea crop. The copper-blight of tea was described by Mr. Shaw, the parasite which causes it not having been previously known to occur in India. A disease of tea seed was investigated by me, and shown to be probably associated with an insect which punctures the seed, and so admits rotting fungi to the tissues of the interior. It is believed that this insect can be fairly easily destroyed.

Other diseases investigated by the section, of which accounts were published during the year, were soft rot of ginger (by Mr. McRae), turmeric leaf spot (by myself), and heart rot of the blue pine (by Mr. Hafiz). Forest diseases, of which the last named is an instance, cause great losses in India; Pusa gives such assistance as it can to the Forest Department, but there is room for a mycologist to work specially at these diseases.

Mr. Shaw is engaged in investigating the root rot of a number of cultivated plants, caused by a species of Rhizoctonia. The parasite appears to be the same in all cases and its complete study, in view of the large range of its victims, is most desirable.

The usual routine work of advising cultivators and the general public interested in agriculture on the diseases of plants and allied matters, which in this section, as in the Entomological, forms a very essential part of the work, was continued. Assistance was also given to Provincial Agricultural Departments in advising on the work of their Mycological assistants, and in providing material for reference collections in their colleges.

7. *Entomology.*—Mr. Lefroy held charge of this section up to the 31st January, 1911, when he proceeded on leave, and Mr. T. Bainbrigge Fletcher, Supernumerary Entomologist, took over charge.

As in previous years, several provinces have freely availed of the assistance offered by Pusa in co-ordinating and checking the work of their Entomological assistants. Of these latter there are now seventeen, some engaged in teaching at the six Provincial Agricultural Colleges, the others in field work. The advisory function of the Entomological Section at Pusa is of great importance in the present position of Economic Entomology in India. The section helps by determining crop pests reported by Provincial assistants, and advises regarding the methods of control likely to be effective in checking them. In several provinces these methods have been demonstrated on a large scale, as in the work against potato moth and surface caterpillars in Bengal, cane grasshopper and potato moth in the United Provinces and several pests in Madras. In Baroda State also, the Entomological Assistant keeps in close touch with Pusa, and has shown much practical energy. In the same connection, mention should be made of the arrangements made directly by the section for demonstrating the life histories and characters of injurious and beneficial insects. A considerable exhibit was

arranged for the Allahabad Exhibition; show cases, coloured plates with brief descriptive leaflets, and coloured lantern slides, were issued for demonstration and distribution to those interested.

Sericulture continues to form an important branch of the work. Eri silk production has been developed as a cottage industry in many parts of India, and received a great stimulus through the display arranged at the Allahabad Exhibition, and smaller exhibits shown at local shows in Bengal. The industry has been taken up by the Agricultural Departments of Bengal and the United Provinces. Difficulty is still experienced in disposing of small parcels of cocoons and thread, the mills being unwilling to buy except in large quantities. Experiments in mulberry silk production have been extended. Crosses were effected between European univoltine and indigenous multivoltine races, with a view to obtaining a robust multivoltine race, yielding silk of better quality than is produced by native forms. Broods of European mulberry silk-worms were successfully reared at Pusa, the resulting thread being well reported on by the trade. Experimental work forms only a part of the activities of the sericultural branch; a great volume of correspondence has arisen in connection with it, and arrangements for the supply of disease-free eggs, castor seed, samples of cloth and machines for spinning, doubling and twisting have required much organising. Twenty students from various parts of India attended the special courses of practical instruction in silk culture during the year.

Lac culture was continued, and a practical training given to students in this subject. A large amount of material was collected, with a view to working out the races of lac insects in collaboration with Mr. Green of Ceylon, a specialist in the group.

Bees of two specially selected Italian strains were imported, and an attempt is being made to acclimatise them at Pusa. Apiculture is still, however, in the experimental stage.

The study of the life histories of injurious insects has progressed, a number of important pests having been reared in the insectary and their habits studied. Mr. Ghosh has prepared a memoir on palm beetles, and Mr. Dutt on some Aculeate Hymenoptera. Other memoirs on life histories are in preparation.

The insect survey of India has been continued as time permits. Large collections have been sent for study by specialists, and to the authors of volumes of the "Fauna of India" series. Mr. Nowrojee has prepared a memoir on some aquatic insects.

The investigation of the damage caused by termites (white-ants), started by Mr. Lefroy in collaboration with Mr. Evans, Deputy Director of Agriculture, Northern Circle, Central Provinces, was continued by Mr. Fletcher. The latter officer was also invited to tour with the Railway Sleeper Commission, to advise on the best methods of reducing the enormous losses caused on Indian railways by these insects, and is carrying out experiments on the preservation of wood from their attacks.

8. *Second Entomological Section.*—This section is engaged in the study of Dipterous insects, and in particular those which suck blood and which may transmit disease. Mr. Howlett, who is in charge of it, only rejoined after absence on sick leave for a year and five months, towards the end of March, 1911. The work of the section was therefore practically in abeyance until the last quarter of the year.

Since his return, Mr. Howlett has had to devote much time to disposing of collections of material accumulated in his absence. The identification of these has progressed with assistance from the Indian and British Museums.

As special work, Mr. Howlett has been engaged in a study of parasites of Tabanidæ ("horse-flies"); the temperature reactions of mosquitoes, temperature apparently being one of the main factors controlling mosquito bite; the relative efficiency of the fish known as "Millions" and other enemies of mosquito-larvæ; and peach flies. In the

latter investigation a method of destroying the male fly, which is simple, cheap and effective, has been discovered, and though it seems improbable that anything short of netting the trees will completely prevent the female reaching them, the destruction of the males should very much reduce the damage done.

While on leave, Mr. Howlett attended as Indian delegate the First International Congress of Entomology at Brussels, and read two papers by Mr. Lefroy and himself. He also carried out, in collaboration with two other gentlemen, a successful series of experiments on the range and rate of flight of house-flies under natural conditions, points of importance in view of their behaviour as carriers of disease. The results were published by the Local Government Board in England.

Since his return, Mr. Howlett has again given invaluable assistance in supervising much of the work of the artist staff, and in advising the other sections in the preparation of illustrations for publication.

In certain respects the work of this section differs widely from that of the other sections at Pusa. It was founded to study Diptera, not only those (comparatively few in number) which are serious crop pests, but also those which convey disease to man and animals. Mr. Howlett's work is, therefore, closely related to the work of the Medical and Veterinary Departments, and it is probable, taking into account the great developments towards a realization of the importance of biting flies as disease carriers, that the activities of the Second Entomological Section will expand in this direction rather than on more purely agricultural lines.

9. *Bacteriology.*—Mr. Hutchinson held charge of this section throughout the year.

Much of his work has been of preliminary nature, confined largely to trial and selection of the bacteriological methods best adapted for dealing with the special conditions of soil and climate in India. The main lines have been aimed at determining under what conditions various

soils will best serve as culture media for those bacteria, naturally present in them, on which the processes of conversion of the organic nitrogen of humus into assimilable nitrates depend.

A special study has been made of the effect of hot weather ploughing on the bacteriological content of the soil, and the possibility of a bacteriological explanation of the undoubted increase in fertility resulting therefrom. It was found that the net result is an extremely rapid formation of ammonia, part of which becomes available to plants and part of which is lost. Depletion of the soil nitrogen is a necessary consequence and the maintenance of fertility must depend on the restoration of this by green manuring or otherwise.

A bacterial disease of tobacco occurring in Rangpur was investigated by Mr. Hutchinson. It was found to be caused by a strain of Bacillus solanacearum, an organism known to cause disease in several cultivated crops, such as potato, brinjal and tomato. The Rangpur strain differs from those described in America and Japan in some of its pathogenic features.

A disease of the Eri silk-worm, which causes havoc in the broods at certain times of the year, was also studied. It was found to be associated with the presence of bacteria in the intestine.

Certain preparations known as Ratin and Trope Ratin, prepared in Copenhagen, have been widely recommended as rat exterminators, and have been suggested for use in India, both with a view to checking plague and to protect crops against the ravages of field rats. Mr. Hutchinson carried out tests of these preparations. Ratin was found to have lost its virulence, but it is suggested that this might be recovered by preparation in India. Trope Ratin was found effective within a limited time after its preparation, but its cost precludes any possibility of its use on a large scale by cultivators. Neither can be recommended for employment at present.

Agricultural Bacteriology in the wider sense, including the bacteriology of industries dependent on agriculture, has made great strides in recent years, and developments in the practical application of this branch of agricultural science in the tropics now appear probable, which were scarcely anticipated when this section was founded at Pusa. Proposals are being made for strengthening the section, which is understaffed.

10. *Training.*—Two different classes of instruction are provided at Pusa. Students are admitted for a post-graduate training in the scientific sections, being ordinarily required to take up a single subject only. Exceptionally, to meet definite requirements of Provincial Departments, which are not in a position to train their own men for such positions as Assistant Director, Farm Manager and the like, post-graduate students have been admitted to a general course, including a period of study in each of the chief sections as well as practical work on the farm. Ordinarily, however, it has been held by the Board of Agriculture that students requiring a practical agricultural training are best provided for by the six Provincial Colleges, and now that these are all in working order, it is not anticipated that there will be much further demand for the post-graduate general course. The second class of instruction given at Pusa consists of short courses of an essentially practical nature in special subjects such as silk and lac culture, cattle and poultry breeding and management, and fruit growing. To these it is hoped to add dairying, for which there is a decided demand which we are not yet in a position to meet, while the course in tillage implements and agricultural machinery was discontinued during the year, as it was not fulfilling any useful purpose. Instruction is imparted in English or in the vernacular, and no educational qualifications whatever are required.

Of the post-graduate students, one continued his course in general agriculture, and one in entomology left after having finished his course during the year. Six students were admitted, two in general agriculture, two in chemistry

and two in entomology. The two students in general agriculture were recalled to their province after completing one year's training, as their services were required by the Provincial Department.

The short courses continue to be popular, students from all parts of India having been admitted. Four took up fruit growing; eight, cattle breeding and management; nine, poultry breeding and management; three, tillage implements and agricultural machinery; twenty, sericulture; and fifteen, lac culture. A certain amount of instruction in bee-keeping was given to some students interested in the subject, but as apiculture at Pusa is still in the experimental stage, regular courses have not yet been established. As far as possible, only those have been admitted to the short courses who propose to take up the subjects taught as a subsidiary means of livelihood to agriculture. In some cases, it was found that non-agriculturists sought admission in order to obtain certificates which would get them employment under Government, especially in Native States. Usually such students were not admitted, or if admitted, certificates were not given to them.

11. *Upkeep of the Estate.*—As a result of the floods, to which the low-lying portions of the farm are subject, and which resulted in a loss of over 100 acres of crops in July, 1910, the Public Works Department was requested to revise the arrangements for draining this part of the Estate, and in particular to repair and strengthen the protective embankments were defective. The flood referred to was probably the highest on record, and gave us a very anxious time, but the bulk of the protective works stood very well, and amply justified the outlay which was incurred on them. The repairs have been deferred pending allotment of funds; fortunately there has been no flood up to date this year.

Two additional blocks of quarters have been constructed departmentally for the use of the staff of the Inspector General of Agriculture, in continuation of those built last year. A new workshop and weigh-bridge for coal were

constructed in connection with the power-house, and plans have been prepared for a coal bunker. The ice plant has been fitted up and is now under trial. It is capable of turning out half a ton of ice in the day. An ice store is being built departmentally. The laboratories consume a good deal of ice which has formerly been obtained from Calcutta, and it is hoped that the new plant will not only prove a convenience but will effect an economy. Much trouble was experienced with the gas supply, owing to the retorts burning out. This culminated in a complete stoppage of gas for some weeks in the hot weather. The Oriental Gas Company of Calcutta kindly spared the services of their Chief Distributing Engineer, Mr. E. P. Reilly, to overhaul the installation. The laying of the retorts was found to be defective, and other minor alterations were carried out under Mr. Reilly's supervision, with the result that no further trouble has been experienced. We are under an obligation to the Company for their courtesy in sending up one of their best engineers to help us.

Provisional estimates for providing a Middle English School for the use of the staff of the Institute and the residents in the neighbourhood were sanctioned, the cost to be borne jointly by the Governments of India and Bengal. The estimates did not provide for residential quarters for the teachers; plans for the school and quarters were prepared with assistance from Mr. Preston, Inspector of Schools, Patna Division, and submitted with revised estimates for consideration by the Bengal Government. Some minor improvements were carried out in the students' hostel.

12. *Library.*—The revised catalogue of the library, corrected up to the end of 1908, was issued. The correction of the proofs and seeing it through the press entailed a great deal of work. The card catalogue was revised, and a register of new additions is now maintained in such a form that further editions of the printed catalogue can be brought out without much trouble. The loan arrangements are working admirably, and I am glad to note that

advantage is being more freely taken of the facilities for borrowing books given to officers of the Provincial Departments. The library is still wanting in many of the more expensive sets of periodicals; the sectional grants for purchase of books usually do not exceed 500 rupees; this is not more than sufficient for current literature, and there is no general grant from which expensive periodicals can be paid for. The new additions amounted to about 1,500 volumes. The library is rapidly becoming overcrowded and proposals for its extension are under consideration. The Director is in general charge of library arrangements and I wish to express my satisfaction with the work of Babu Anukul Chandra Chatterjee, the Librarian.

13. *Publications.*—The Journal, Memoirs and Bulletins were continued. As the Department expands, more work is submitted for publication, the Provincial Departments supplying an increasing volume of contributions. The grant for publications was reduced during the year, and transferred to the budget of the Inspector General of Agriculture. Much of the publication work is now done by the Inspector General, who is Editor-in-Chief, the Pusa staff supervising the illustration work and also acting as an advisory committee. The free distribution list was considerably curtailed during the year, consequent on the reduction of the grant.

14. *General Health of the Station.*—The general health of the station during the year under report was good. Relief was afforded to 7,657 new cases, of which 7,477 were treated in the outdoor department, and 180 admitted as indoor patients. This is an increase of 1,426 cases over last year's total. The increase in attendance was due to the great prevalence of malarial fevers, and cholera, in the surrounding villages. One hundred and forty-six cases amongst European officials and families were attended to, an increase of 47 over last year's total. The daily average number of patients treated was 7·87 indoor and 49·05 outdoor, as against 6·96 and 48·97 respectively during the previous 12 months.

Four deaths occurred in Hospital,—two from malarial cachexia, one from Bright's disease and one from neglected hernia.

Two cases of cholera occurred amongst the families of the Indian staff in August, 1910, with one death. Immediate and successful measures were taken to prevent the disease spreading on the Estate.

One hundred and one surgical operations were performed: of which eight were major and the remainder minor.

The prevailing diseases were malarial fevers, *kala azar*, bowel complaints, rheumatic complaints and skin diseases. Blood diseases were diagnosed microscopically.

Quinine was issued prophylactically on the Estate towards the close of the monsoon.

Fourteen primary and ten re-vaccinations were performed in the early part of the year.

All drains in the building area of the Estate were made pucca during the year. A small cemetery was constructed departmentally. The number of residents within the Estate was over 700 on the date of the recent census.

15. *Accounts.*—The total expenditure incurred during the current year was Rs. 2,99,587, as against Rs. 3,12,427 of the preceding year. The principal items of expenditure are pay of gazetted officers and establishment Rs. 1,87,383, travelling allowance of officers and establishment Rs. 22,315 and farm expenditure, scientific apparatus, books, fuel, stores for electric and gas installation, contingencies, etc., Rs. 89,889. The grant for the "Agricultural Periodicals and Journal" has been transferred from this office budget to that of the Inspector General of Agriculture in India from 1st April, 1910.

The gross receipts during the year by sale of farm produce, milk and other miscellaneous articles, and Mr. Lefroy's book "Indian Insect Life," amounted to Rs. 13,462, as against Rs. 5,573 in the preceding year. Of this amount the sale proceeds of "Indian Insect Life" accounted for Rs. 5,490.

16. *Visitors.*—During the year under report the Hon'ble Mr. E. D. Maclagan, C.S.I., I.C.S., Secretary to the Government of India, Revenue and Agriculture Department, the Hon'ble Mr. F. C. Gates, C.S.I., I.C.S., Financial Commissioner to the Government of Burma, Mr. R. Inouye, Assistant Professor, Agricultural College of Tokio Imperial University, Mons. H. Brenier of the Commerce and Industry Department of French Indo-China, and Dr. Vermoesen, Mycologist Elect to the Belgian Congo, visited the Institute. Dr. Vermoesen worked in the Mycological laboratory for over two months at the end of the year.

REPORT OF THE IMPERIAL AGRICULTURIST FOR THE YEAR 1910-11.

(A. C. DOBBS, B.A.)

Charge of the Pusa Farm during the greater part of the period under report was held by Mr. G. Sherrard, Assistant Agriculturist. The services of the Assistant Inspector General of Agriculture were also placed at the disposal of the Director for farm purposes, and in fact Mr. A. McKerral wrote the Annual Report for 1909-10.

In June 1911 Mr. Sherrard left Pusa to take up the appointment of Professor of Agriculture at the Bengal Agricultural College, Sabour.

Mr. H. Southern was at Pusa as Supernumerary Agriculturist from November 1910 to February 1911, when he left to go to Madras, where he is officiating as a Deputy Director of that Province.

Mr. Ikramuddin held the appointment of First Overseer and Mr. Ziauddin Hyder that of Second Overseer throughout the year.

Mr. Judah Hyam continued in charge of the breeding herd and Mr. Nizamuddin Hyder of the poultry. Mr. L. S. Joseph was appointed Veterinary Assistant in May 1911, and has taken charge of the current duties of the Overseer during Mr. Judah Hyam's absence on privilege leave.

Mahomed Yakub Mukadam of the Lyallpur Farm was appointed as Surveyor in May 1911.

The farm staff is to be congratulated on the thorough and timely preparation of the land for both the *rabi* and monsoon crops which is noted below, and the veterinary staff on the condition, and continued freedom from disease, of the breeding cattle.

Tours.—Mr. Sherrard visited the provincial farms at Dacca and Sabour in December.

Many members of the staff attended the Allahabad Exhibition in connection with the Pusa exhibits.

Training.—Mr. Fatehuddin, B.A., Assistant Director of Agriculture for the Punjab, continued his course in general agriculture during the whole period under report.

Babu B. L. Mukerji, B.Ag., and Babu B. B. Das, B.Ag., stipendiaries of Eastern Bengal and Assam, attended the course of general agriculture from July 1910 till March 1911, when they left to take up their duties at Dacca.

Mr. A. B. Hay-Webb worked on the farm as a visitor from 2nd to 27th March 1911.

The numbers of students attending the short courses have been :—

Cattle-breeding	8
Poultry Management	9
Tillage Implements and Agricultural Machinery .	3*

Character of the Season.—The monsoon of 1910 was early. The rainfall was somewhat small (about 33″), but very well distributed and, in spite of the loss of the crops on large areas of low-lying ground owing to the river rising to a level higher than any previously recorded and owing to the breach of a bund that had previously protected the farm, the crops provided an amount of silage very much greater than the requirements of the cattle for one year. Over 4 inches of rain fell in October, thus ensuring an ample supply of moisture for the greater part of the *rabi* season, and as the sowings were completed at an earlier date than in any previous year since the establishment of the farm, these crops obtained an exceptionally favourable start, which enabled them to give a very good yield in spite of the fact that no further appreciable quantity of rain fell before harvest.

Rain also fell early in June 1911, and, owing again to the land having been thoroughly prepared beforehand, practically all the crops were sown before the end of the month and give excellent promise.

* This course has since been abolished as it has been found to serve no useful purpose.

Cropping.—The greater part of the farm was, as usual, devoted to growing fodder and grain for the working bullocks and the breeding herd. Maize, sorghum, oats, peas, khesari (*Lathyrus*), gram (*Cicer*) and *arhar* (*Cajanus*) were the principal crops grown for these purposes.

The maize provided a large quantity of excellent silage; that from the sorghum was not so good, much of it being decayed, and the right stage at which to cut this crop for siloing under the conditions obtaining here has yet to be ascertained. The oats provided a large amount of excellent feed both of grain and straw. The area of pulses grown was not, however, sufficient to make purchases of this class of food unnecessary.

Much of the *arhar* was spoilt by the floods.

A considerable area was, as usual, sown with Sann hemp for green manure.

Guinea grass, growing on nearly 3 acres within the influence of the bamboo avenues, gave over 300 maunds per acre of green fodder, with only two irrigations in the dry season; lucerne, with constant irrigation, gave over 200 maunds per acre.

Other crops grown on a small scale were flax (which had to be destroyed because of the appearance of dodder) and paddy. Experiments with paddy were inconclusive, the difference between the yields of the plots not exceeding the margin attributable to error.

The projected growth of varieties of wheat in extension of the work done by the Imperial Economic Botanist was abandoned. A large number of crops were grown, on small plots, under observation and for experiments carried on by the scientific officers.

Soybeans, obtained from Nagpur, yielded nearly 7 maunds per acre, which is not sufficient to pay for the cultivation and for the occupation of the land for two seasons.

Permanent Manurial and Rotation Experiments.—These were continued in accordance with the original scheme and the result recorded for future reference.

Permanent Pasture.—The manurial experiments were abandoned this year. There seems to be no doubt whatever that the direction which the experiments on pasture here should take is that of ascertaining the extent to which systematic grazing and extensive surface cultivation, combined possibly with the sowing of quick-growing catch crops, will enable land that cannot be economically used except as pasture to be maintained in a reasonably productive and profitable condition. The upland pasture is now ploughed up every three years and replanted with *doob*, but the *doob* does not look well on close examination even in the first year after planting, and disappears rapidly during the second year. A small part of the ploughed land has been sown with Sann-hemp this year for ploughing in before planting the *doob*.

Thrashing.—A record was established in thrashing the oats this year, 241 maunds being thrashed in one day. The heavy yield of grain, amounting on one field to 33 maunds per acre, no doubt contributed to this result.

Clearing and Levelling.—A large kiln was cleared from the former brick-field and a road across this area laid out and part constructed.

Work-cattle.—The number of cattle in use has been increased by the breaking-in of young cattle, purchased, and supplied from the Montgomery herd. The Montgomery cattle are rather slow, but can pull heavy loads. Foot-and-mouth disease broke out among the working bullocks towards the end of the monsoon of 1910, but was checked and suppressed by prompt measures.

Breeding Herd.—The Montgomery herd has been maintained in excellent condition, and the numbers of cows and heifers increased during the year. Fifty-four cattle were sold and four transferred to the working cattle during the year.

Only three animals died—less than 2 per cent., which is a very small percentage considering that the greater number of the cattle are cows and young calves.

Sheep.—The Gorakhpur sheep have done well, and the cross between them and the Dumbha ram appears to be successful.

Poultry-breeding.—One or two of the varieties of poultry originally imported have proved failures, and others have been substituted for them. Indigenous varieties have been obtained and appear in some cases to be worth keeping. But the work cannot yet be said to be beyond the experimental stage. The distribution of eggs by post and rail has been discontinued, but a considerable number of fowls have been distributed to the provincial farms and sold to private persons.

Programme of work for 1911-12.—1. *Cropping.*—An endeavour will be made to bring the different areas of the farm under systematic rotations suited to each and to the requirements of the cattle. It is proposed to increase the proportion of leguminous crops, and, in view of the excess of fodder provided by the present cropping, to reintroduce revenue-producing crops such as wheat, oil-seeds and possibly tobacco, on a small scale.

2. *Pasture.*—It is proposed to try simple experiments on the effect of surface cultivation and the sowing of leguminous catch crops on pastures.

3. *Laying out.*—The clearing of the former brick-field will be continued when time can be spared. The systematic grading of the fields all over the estate towards the roads or drains, so as to prevent the accumulation of water in patches in the centre of the fields, will be kept particularly in view.

Steps will be taken to prevent erosion and "washing" during heavy rain in a few places where it now takes place.

4. *Breeding-herd.*—The improvement of the milking capacity of the Montgomery herd will continue to be the principal object in view.

5. *Sheep.*—The production of cross-bred sheep with a view to ascertaining the suitability of the Gorakhpur Dumbha cross for mutton production will be continued.

6. *Poultry.*—Further trial will be given to some of the breeds already imported, the requirements of the provincial farms will be kept in view, and indigenous breeds will be further studied. The number of different breeds will probably be considerably reduced.

REPORT OF THE IMPERIAL AGRICULTURAL CHEMIST FOR THE YEAR 1910-11.

(J. WALTER LEATHER, PH.D., F.I.C.)

Charge of Section and Establishment.—The section was in charge of myself during the entire year.

Mr. H. E. Annett, Supernumerary Agricultural Chemist, acted as Agricultural Chemist, United Provinces, until 10th November 1910. He again went to Cawnpore on 24th June 1911 to act as Principal, Agricultural College.

The changes involved during the year have been as follows :—Babu Subodh Chandra Kar, M.A., the second assistant, died on 19th July 1910. Subodh Babu joined the establishment at Dehra Dun in 1902 as a volunteer assistant and gradually rose to the position of second assistant. He had shown unusual ability and would no doubt have risen to still higher office. His death was a very severe loss. Babu Jatindra Nath Mukerjee, B.A., B.Sc., the third assistant, has been appointed second assistant. Mr. Bhailal Motibhai Amin, B.A., who was promoted third assistant, has, during the year, been appointed on deputation as assistant in the laboratory of the Behar Indigo Planters' Association. Mr. K. S. Vishwanatham, B.A., was selected by the Imperial Bacteriologist as his second assistant. Babu Adhar Krishna Bose was selected by the Scientific Officer, Indian Tea Association, as his assistant. The latter changes, although occasioning loss to the establishment, must be considered in the light of a compliment to the section and fulfil one of its important functions. Other changes have been as follows :—Mr. G. K. Lele, L.Ag., Nagpur, was appointed a junior assistant in August 1910; Mr. D. K. Ambekar, M.A., had to resign his appointment in April on account of family reasons; Mr. R. C. Sohoni left at the end of his probationary period.

Meteorology.—In addition to the ordinary meteorological records, the record of evaporation, which was mentioned in the last annual report, is being maintained. A record of soil temperatures has also been commenced during the year and will yield information as to diurnal and seasonal variations of temperature. Self-recording hygrometer and barometer will also be set up. Most of the information provided by these records will become immediately useful in connection with one or other investigations at the Institute.

Drainage Data.—These are being continued, and the first several years' records together with those of the Cawnpore gauges have been written up for publication. Among the deductions which have been possible are the following:—(*a*) The amount of water draining away annually varies with the rainfall, it being large in wet years; but the amount which evaporates from bare fallow soil is almost constant for any one place. At Cawnpore about 18″ of water thus evaporates per annum, at Pusa about 28″; the corresponding figure at Rothamsted is about 15″. The explanation for the larger amount evaporating at Pusa than at Cawnpore probably lies chiefly in the nature of the soil, but this is a matter which remains to be demonstrated. (*b*) Drainage from cropped land is naturally affected by the extra factor—the crop—and the drainage data have yielded some very interesting information in regard to it. On the one hand a crop transpires large amounts of water; on the other its presence acts as a "shield" to the moisture of the surface soil preventing it, in a measure, from evaporating. Thus the crop introduces into the question two factors, which are mutually opposed to one another, and the amount of drainage occurring from cropped land will be greater or less according to the magnitude of their respective influences. The effect of good crops growing on the Pusa and Cawnpore gauges has been to reduce direct evaporation to two-thirds or one-half of what the soil would have suffered had no crop been present. How much this "protective" effect is, when converted into inches of water, naturally de-

pends on the season of the year. During the dry season the general loss from this cause is much less than during the monsoon; hence the "protection" provided by a "rabi" crop will be generally much less than that of a "rains" crop; the former may be 2″ or 3″, the latter 7″ or 8″ of water. (*c*) The amount of water which runs off the land during heavy rain is known to vary within wide limits, and although the gauges have yielded some information on the subject, it relates to only one soil maintained perfectly level. No very explicit deductions are therefore possible, but the general conclusion has been drawn that perhaps popular ideas have exaggerated its amount.

The Amount of Nitrate in Soils.—This subject is one which has long been considered of great importance, and the drainage water from the gauges, as also some field records, have added much to our knowledge of the subject in so far as India is concerned. The total amount annually formed in fallow land is very much greater—twice or three times—than at Rothamsted. Then another feature has appeared, namely, that nitrification is not active throughout the dry weather, that is in fallow land—not irrigated; absence of moisture in the surface soil during a part of this period might be a controlling factor, but it is not a complete explanation, because the sub-soil is always moist, and here nitrification is similarly restricted to the monsoon. Nor does the variation of temperature offer any better explanation. With the advent of the monsoon, however, nitrates form with astonishing rapidity, the occurrence being most marked immediately after the first heavy rain. This investigation promises to prove of great interest.

The Water Requirements of Crops.—Allusion has been made in previous reports to this subject, and a second memoir, No. 10, Chemical Series, has been published. In continuation of what was published in Memoir No. 8, it has been found that the nature of the soil has no effect on the Transpiration Ratio; at the same time this factor has a great influence on the rate of water movement, and hence indirectly on the weight of crop produced. Field experi-

ments over several years have shown that practically the whole of the water assimilated by a crop is obtained within the root range, some 6 to 7 ft. in alluvial soil, and that although the stores of water present below this depth are very great, they are substantially of no service to the plant. The field experiments were at the same time utilised to check the values of the Transpiration Ratios which had been found by pot-culture methods. The two methods yielded very similar values for this factor.

The investigation into the *availability of plant food* in soils is being continued, but many difficulties have been met with, and its progress is slow.

Usar Land.—Reference was made to this subject in the last report, and the work has been extended. The first investigation had to do with a certain stretch of land in the Mainpuri District, and a very exhaustive series of tests showed that this class of usar land not only contains sodium carbonate, but is also highly impervious to water. The amount of movement of water, whether in the downward direction during wet weather, or towards the surface during the dry period, is thus necessarily only small; consequently also there cannot be any large amount of movement of salts.

Experiments made at Pusa on this soil have shown that by the application of common salt its physical state can be altered and the salts washed out. Rice was grown on some of it last year and is now growing again, but the method is, I fear, not financially feasible. In other experiments also made by pot-culture at Pusa, the physical defect (imperviousness) was separated from the chemical defect (alkali salts) and then plants sown. It was then found that of the two the alkali was the more pernicious.

During the past cold weather the investigation has been continued in another direction in collaboration with the Irrigation Department. One of the features of this alkali land is frequently the occurrence of "alkali spots" in the middle of fields otherwise quite fertile. It has been frequently argued that these result from the presence of

canals and excessive irrigation. The fact that the introduction of a canal is accompanied by a rise of the sub-soil water level has lent support to the argument. The two features are, however, distinct, and it certainly does not *necessarily* follow that they are related. We have some soil, taken from *fertile* land in the immediate neighbourhood of alkali spots under observation; it is maintained fallow with an artificial sub-soil water-supply at 2 ft. from the surface, and the experiment should show whether it will thereby become "alkali."

But the work of the past cold weather dealt with another aspect of this question. It is not only in canal-irrigated areas that "alkali spots" occur in cultivated fields; they are to be found in well-irrigated tracts also. It was decided, in consultation with the Director of Agriculture and the Superintending Engineer, to take samples from a series of such "alkali spots" situated (*a*) within a canal-irrigated tract, and (*b*) within a neighbouring well-irrigated tract, and to compare them by means of such methods as we at present possess. A suitable tract of country was found in the Muttra and Etah Districts. In the Sadabad (Muttra) and western part of Jalesar (Etah) parganas is a tract of country under well-irrigation, and alkali spots occur in many of the fields; thirty such alkali spots were sampled to a depth of 9 ft., excepting in cases where the kankar was too hard to drill through. In the eastern half of pargana Jalesar the irrigation is principally from the Etawah branch, Ganges canal, and in this tract twenty-nine alkali spots were similarly sampled to a depth of 9 ft. In each case a separate sample of every succeeding 6″ was taken, and the whole of the specimens are now under examination. The first tract named is particularly suitable because although it has always depended on well-irrigation, the new Hathras branch of the Ganges canal is under construction, and the tract will hence shortly come under the influence of canal irrigation. All the fifty-nine alkali spots have been registered, mapped to show the approximate area, and the exact position of the boring, from which

the sample was taken in February, registered by means of distance and direction from a stone bench-mark especially put down on the field border. We shall thus not only have the results of the comparative tests of the present year, but it will be possible to form a very exact opinion at a future time, say ten or fifteen years hence, as to whether the introduction of canal irrigation has caused either an increase of the area of these "alkali spots" or any increase in the percentage of "alkali" in the soil. The tests of the soil of experimental plots near Aligarh which were referred to in last year's report showed that the only *really* effective means which had been tried was gypsum, and in that case the cost had been prohibitive. The land which Mr. Keventer has reclaimed was especially interesting. By the application of very large amounts of manure and liberal irrigation, crops have been grown for a number of years on some very bad alkali land. But the samples taken to a depth of 9 ft. showed that the result of the treatment had been to reclaim only the top foot of soil, and that below this layer, the soil is as bad as it was originally. The crops subsist in fact on the liberal manure supply of the top soil and can even then only succeed by the aid of frequent irrigation.

Date Palm.—Immediately after his return from Cawnpore, Mr. H. E. Annett took up, at my suggestion, the general investigation of the Date Palm Sugar industry. Hitherto nothing had been done in relation to the chemistry involved in this industry, and it is obviously desirable that this omission should be rectified. Mr. Annett toured twice in the Jessore District, which is one of the principal centres, and carried out a series of analyses of the juice on the spot and later on of raw sugar at Pusa, besides collecting much valuable information in regard to the methods which are employed. The work will be continued on Mr. Annett's return from Cawnpore.

Saltpetre.—During the year an attempt has been made to work out the practical details of an improved method of refining crude saltpetre which had occurred to me some

years ago as possibly feasible. The chief defects of the present methods are (i) the considerable time required in order to obtain the refined product, (ii) the amount of fuel used is greater than it should be, (iii) a serious loss of nitrate occurs, (iv) much of the refined saltpetre is of low quality, (v) the colour of the refined saltpetre is often brown instead of white, (vi) refining is often interrupted during the rains period.

After working on a laboratory scale, an apparatus was constructed which would deal with a maund of crude saltpetre per charge, and this was worked daily at the Allahabad Exhibition. It was in charge of Babu Jatindra Nath Mukerjee, who has carried out the whole of the experimental work connected with the process. The process is successful in largely eliminating the defects enumerated; nearly nine-tenths of the potassium nitrate in the crude saltpetre is obtained during the day as a white refined saltpetre of over 90 per cent. purity; no water has to be evaporated, and the process is independent of the weather. The other fraction of the potassium nitrate, which is not obtained by this process, remains in the muds and can be extracted by present methods.

The process created a great deal of interest among the refiners who visited the Exhibition, but there is naturally a considerable difference between entertaining an interest and actually replacing the present methods by a somewhat costly machine, and no definite opinion can be formed as to whether the new process will be adopted until it has been tried on a reasonably large scale, so as to form an accurate idea of the actual cost of working it. A proposal is at present under consideration to erect the plant at a refinery in Behar. A Bulletin has also been written on the subject.

Education.—There are two students from the United Provinces and Bengal, respectively, at present undergoing training, and another is to come from Travancore State. There are also two probationary assistants who have recently joined this section, who are in the position of students.

Programme of work for 1911-12.—1. The work on the availability of plant food in soils will be continued.

2. In relation to moisture requirements of crops, the current work has to do with the moisture conditions necessary to a green manure crop.

3. The investigation on Usar will be continued on the lines indicated in the body of this report.

4. The chemistry and manufacture of Date Palm Sugar will be investigated by the Supernumerary Agricultural Chemist.

5. Improvements in the refining of saltpetre will continue to be studied.

6. *Education.*—This requires no special comment and will be conducted according to the lines laid down.

Publications.—The following papers have been published :—

Memoir No. 10, "The Water Requirements of Crops in India—II," by Dr. J. Walter Leather, June 1911.

Bulletin No. 24, "The Indian Saltpetre Industry," by Dr. J. Walter Leather and Babu Jatindra Nath Mukerji, August 1911.

"Sugar-cane in India," published in the Agricultural Journal of India, Vol. VI, Part III, by Dr. J. Walter Leather.

"Chapter on Industrial and Agricultural Chemistry" for the Report of Board of Scientific Advice, by Mr. D. Hooper and Dr. J. Walter Leather, 1909-10.

"The Loss of Water from Soils during Dry Weather." Report of the Seventh International Congress of Applied Chemistry, by Dr. J. Walter Leather, 1911.

"The Transpiration of Water by Plants in the Tropics." Report of the Seventh International Congress of Applied Chemistry, by Dr. J. Walter Leather, 1911.

"The Effect of Manure on the Composition of the Grain of Field Crops." Report of the Seventh International Congress of Applied Chemistry, by Dr. J. Walter Leather, 1911.

REPORT OF THE IMPERIAL ECONOMIC BOTANIST FOR THE YEAR 1910-11.

(A. HOWARD, M.A., A.R.C.S., F.L.S.)

Part I.

Teaching, Training and Staff.

Charge.—I held charge of the section during the year under review except for the first 28 days of July when I was on privilege leave and on special duty in England.

Up to the end of July Maulvi Abdur Rahman Khan, Second Assistant, was in charge of the section. During my deputation to the Kashmir State in August and September 1910, he was also in charge of the current work at Pusa. In consequence of the satisfactory manner in which this assistant carried out his duties during five months in my absence in 1910, his services were rewarded by the grant of a special charge allowance for the whole period in question.

Students.—Four short course students attended the section during the year. Three of these worked well, especially the two sent from the Lushai Hills by Major Cole.

Staff.—In addition to the work done by my second assistant, Maulvi Abdur Rahman Khan, during my absence from Pusa in 1910, which has already been referred to, I have pleasure in recording the promising work of this assistant in Economic Botany. The third assistant, Munshi Ijaz Husain, who was in charge of current duties at Pusa on two occasions for short periods, has also improved in his work and made himself useful in connection with the tobacco-curing experiments. The work of the rest of the staff was satisfactory.

Part II.

Special Work in England.

To enable me to complete the work referred to in this section my privilege leave was extended by 17 days to a

period of three months. During this time the work done was the following :—

Wheat.—One of the directions in which the improvement of Indian wheat has been attempted at Pusa has been the increase in rust-resisting power of the kinds at present in cultivation in the plains. This is a subject which has on several previous occasions occupied the attention of the Government of India, but little or no results of practical value have been obtained in the past. It was found at Pusa and at Lyallpur that although the types at present in cultivation differ considerably in rust-resisting power, and that in consequence a considerable improvement in this character is possible by simple isolation methods, nevertheless India does not possess any wheats with the same power of withstanding rust as is shown by many of the wheats of Northern Europe, and especially by American Club. The quality of resistance of the best Indian wheats is of quite a lower order than that possessed by the wheats grown under the more adverse climatic conditions of the North Temperate Zone. This is seen not only when the two classes are grown side by side in India, but also when they are cultivated together in England. One of the directions, therefore, in which improvement might be attempted was, in the light of the work already done at Cambridge on the inheritance of rust resistance in wheat, the production of new kinds by hybridization between Indian wheats and some rust-resistant forms from Northern Europe or America. Attempts to carry this out in practice at Pusa failed on account of the impossibility of getting the rust-resisting parents to flower in time for crossing to be done and for the resulting grain to ripen before the hot weather set in. This difficulty was overcome by sending the Indian parents to Cambridge for spring sowing in 1910 and by carrying out the actual hybridization work in England. Thanks to the facilities given by Professor Biffen at Cambridge, crosses were made by us between various Indian types and American Club and other rust-resistant wheats at Cambridge, and the first generation of the hybrids was

grown at Pusa during the past wheat season. A duplicate set of these seeds was also successfully grown for us at the Cawnpore Experiment Station by Mr. H. Martin Leake, Economic Botanist to the Government of the United Provinces. Now that the difficulty of growing the first generation in India has been overcome, it is expected that among the progeny of these crosses wheats will be isolated of much greater rust-resistance than any of the types now grown in India. The work will be pushed on as rapidly as possible, and it is hoped before very long to have the results on a field scale.

Advantage was taken of my visit to England to consult with Mr. A. E. Humphries, Past President of the Incorporated National Association of British and Irish Millers, on many matters connected with the milling and baking qualities of Indian wheat and to go over in detail the samples sent to England for testing in 1910. I obtained a large amount of valuable technical information on the quality of wheat and also took full opportunity of discussing in detail the lines of future work on the improvement of Indian wheat. I consider Pusa has been exceedingly fortunate in securing for the milling and baking tests not only the invaluable assistance of an authority of the standing of Mr. Humphries in the wheat trade, but also his active interest in the work of improving the crop in India. I consider it will be far better in every way to continue to have the final tests of Indian wheats done in England than to attempt to carry out the work at Pusa under laboratory conditions. Results obtained under such circumstances in India will never carry the same weight as the opinion of the best available expert in the milling and baking trade.

In order to compare the appearance of the new Pusa wheats with those now on the market from various parts of the world, I visited Mark Lane with Mr. Humphries and the Liverpool Corn Exchange with Mr. Broomhall, the proprietor of the *Corn-Trade News and Milling*. It was acknowledged that there were no wheats on the market superior in combined appearance, quality and condition to

the best Pusa wheats. As far as quality only is concerned, Indian wheats are somewhat inferior to Manitobas, but in their greater dryness and in the greater thinness of the skin our best Pusa wheats at least make up for their slight lack of quality. As wheats are sold entirely on the appearance of the samples taken from the ships, it is of the greatest importance to the Indian wheat trade to keep the various grades of Indian wheats separate and not to mix red and white, hard and soft wheats in the same sample. This lowers the price that would otherwise be obtained, while adulteration with earth and other seeds does still greater harm. I saw several good samples of Indian hard white wheat at Mark Lane entirely spoiled by admixture with soft white and red wheat and with dirt and other seeds. A great work remains to be done in teaching the Indian cultivator the great importance of quality, uniformity and appearance in the wheat grown for sale in Europe. In Liverpool, the Pusa wheats were greatly admired and were shown to a meeting of Liverpool millers by Mr. Broomhall, who, in returning the samples to me in London, wrote : " I have just sent you back the samples you left with me. I have shown them to several of our millers who have greatly admired them. The wheat appears equal in value to the best Manitoba." (Letter dated July 8th, 1910.)

While at Liverpool the opportunity was taken of visiting the large new Grain Elevator recently erected by the Liverpool Grain Storage and Transit Company, which embodies all the latest American and Canadian improvements in construction.

Tobacco.—In connection with the work in progress at Pusa on the improvement of Indian tobacco, arrangements were made with one of the Directors of the Imperial Tobacco Company in London to visit two of the best factories in London to see the types of leaf made use of in England. These visits were of the greatest use, and some of the information obtained was applied in the tobacco-curing experiments at Pusa during the past year.

Hops.—In anticipation of my deputation to Kashmir to advise the Durbar on the improvement of the hop industry in that State, three visits were paid to Kent to see the latest forms of hop-drying oasts and the developments which have taken place in hop growing during the last five years. The information obtained was made use of in my subsequent visit to Kashmir.

Fruit packing.—In connection with the proposals for developing the fruit industry of Baluchistan then under the consideration of the Secretary of State, some time was devoted to studying the methods of packing and transporting fresh fruit both in use in England and also employed by the various countries which export fruit to London. Very valuable information was obtained which will be of considerable use in working out the best methods of sending fresh fruit from Baluchistan to India. By a fortunate circumstance I got in touch with one of the Directors of the largest company in Great Britain engaged in the manufacture of fruit-packages on the American system, and in consequence have had no difficulty in importing into Baluchistan a large selection of model packages and packing materials for use in the experiments of the present year.

A study of the methods of packing used for transporting fruit from France, the Channel Islands and South Africa to London shows how backward India is in this respect and what great improvements are necessary in this country.

Part III.

The Hop Industry in Kashmir.

In accordance with the orders of the Government of India the months of August and September 1910 were spent on deputation in Kashmir for the purpose of advising the Durbar as to the best means of extending and improving the hop industry. A detailed report on this subject was submitted, which was afterwards printed by the State.

At present hop growing in Kashmir is in a very primitive condition, the average yield of sun-dried hops being less than 2½ cwt. to the acre, or one-fifth the average yield of Kent. In spite of this, however, the net profits are very great, and for the last sixteen years have averaged about 130 per cent. or over £7 an acre.

The natural advantages possessed by Kashmir as a possible competitor in the world's hop production are considerable. Labour is cheap, plentiful, easily trained and easily managed. The soil of considerable areas of the valley is suitable for hops, while irrigation water is abundant, should it be found necessary to supplement the rainfall. Insect and fungoid pests are almost entirely absent, while the cost of transport to India is likely to be much cheaper as soon as the rope railway to Jammu is completed. These advantages, however, are not likely to be utilised to the full unless the Durbar decides to take the necessary steps to place the industry on modern lines.

In the details of cultivation, irrigation, training, picking and drying there is great room for improvement, and it was a great surprise to me to find that even a crop of 2½ cwt. of saleable hops could be produced under present conditions. The cultivation of the crop is exceedingly defective, and a large amount of moisture is lost by the dense growth of grass and weeds and the absence of a surface mulch. This necessitates surface irrigation and the consequent hardening of the land and loss of tilth. Beyond the provision of single poles there are no attempts at training, so that there is insufficient space for the free development of bine and hops. The drying is done on sheets in the sun, and during this process the hops are a good deal broken, and a large amount of lupulin is lost.

In my report an attempt was made not only to present the scientific principles which underlie modern hop production, but also to indicate the improvements which are possible if it is decided to continue the industry on the present lines. In addition the steps were indicated that would be necessary if hop growing in Kashmir is to be placed on

modern lines and if Kashmir is to enter the markets of the world as a competitor with California.

In addition to the work on hops two other matters were dealt with in Kashmir at the request of the Revenue Minister. The first was an investigation into the wine industry, which is carried on by the State near Srinagar, and the second related to a general scheme for the improvement of the agricultural and horticultural industries of the State. In the case of wine industry, I recommended that this should be given up and the past expenditure in this direction regarded as a bad debt. As regards the development of the agricultural industries of the State, I drew up a detailed scheme in which many directions of improvement were indicated, and in which I recommended the amalgamation of the present agricultural and allied efforts of the State into one strong department under a competent European officer with the necessary experience. Time did not permit me to make all the necessary enquiries into a fourth subject on which my advice was asked for by the Revenue Minister and by the Minister for Education. This related to the introduction of Agricultural Education into the State, on which no useful suggestions could be made without first of all going into the present educational system as a whole.

Part IV.

The Development of the Fruit Industry of Baluchistan.

The proposals put forward by this section in 1909 for the development of the fruit industry of Baluchistan were, during the year under review, finally sanctioned by the Secretary of State, and work was commenced at Quetta in May of the present year. This extension of the work of the section has necessarily involved not only some reorganisation of the work at Pusa, but also an extension of the staff. The Pusa work both in training and investigation is now in great measure limited to *rabi* crops, thereby allowing the months May to September to be devoted to

fruit work in Baluchistan. The staff has been strengthened by the addition of a new appointment, that of Personal Assistant, which was given to a candidate who had worked in this section for nearly five years previously as a volunteer.

During the months May and June of the present year the lines of future work on the fruit industry of the Province have been worked out in detail, and a scheme has been put forward which has been accepted by the Local Government.

This falls into three parts. In the first place, a modern fruit experiment station will be started for the purpose both of demonstrating improved methods of producing and transporting fruit and also of affording facilities for further experiments likely to be of practical value to the country. One of the features of the new experiment station will be a nursery in which the best varieties will be propagated in large number for distribution to the zemindars. In the second place, a neglected fruit garden will be taken in hand, and methods of renovation will be commenced this year. Thirdly, steps are being taken to work out the most suitable methods of grading, packing and transporting fruit so as to make the most use of the present facilities for railway transport to India.

The country round Quetta has been explored, and a suitable site for the new experiment station has been selected, and steps have been taken by the local Government to acquire the land. The Honourable Colonel Ramsay, C.I.E., Agent to the Governor General in Baluchistan, who has strongly supported the scheme from the beginning, has placed a large fruit garden at my disposal for the renovation experiment. It is hoped that a beginning will be made with the packing experiments during the present year, and the necessary buildings for the fruit experiment station will be erected by September next.

In the preliminary work involved in the scheme I have been greatly assisted by the Political Officers stationed at Quetta. Mr. H. R. C. Dobbs, I.C.S., C.I.E., Officiating

Revenue and Judicial Commissioner in Baluchistan, has furthered the scheme in every way possible, while I am greatly indebted to Colonel McConaghey, Political Agent, Quetta-Pishin, and to Captain Keyes, Assistant Political Agent, Quetta, for the ready manner in which they have placed their wide knowledge of the country and of the people at my disposal.

Part V.

Investigations.

Wheat.—During the past year the Pusa wheat experiments have been extended in several directions, and results of great value have been obtained.

Seed Distribution.—A beginning was made during the year at several centres in the growth of Pusa wheats for seed distribution purposes. In Behar two planters volunteered to take up the work in 1910, and in both cases the yields obtained were far in excess of those obtained by the people with the local wheats. The seed thus obtained has been widely distributed to other planters, with the result that over 1,000 acres of the new wheats will be sown next October in Behar at a large number of centres. Over 100 maunds of surplus seed grown in the botanical area at Pusa was distributed last April in Behar alone, the demand greatly exceeding the supply. In the Central Provinces some of the early Pusa varieties were grown by Mr. Clouston, Deputy Director of Agriculture, at the Raipur Farm on a fairly large scale. Both in yield and quality these wheats proved superior to the large collection of other Indian wheats grown there. A further supply of other rapidly maturing wheats was accordingly sent to Raipur last April, and the best of these will be grown on a large scale by Mr. Clouston for distribution, mainly in the Chattisgarh Division. Incidentally the wheat experiments at Raipur during the past season indicate that organic matter in the right condition is the limiting factor in wheat production in this tract. This matter is being taken up by

Mr. Clouston, and when the best method of enriching the soil by green manuring has been worked out I feel confident that wheat growing in this and similar tracts will at once be placed on a higher plane. In consequence of the satisfactory results obtained at Raipur, arrangements have been made with Mr. Evans at Hoshangabad for the trial of one of the earliest of Pusa wheats at that station. In the United Provinces the methods of cultivation of wheats which have proved successful at Pusa were tried on a large scale in the botanical area at Cawnpore by Mr. H. Martin Leake, Economic Botanist to the Government of the United Provinces. Both in yield and appearance of the grain the results obtained were very much better than those realised in the district. The Cawnpore results are particularly valuable, as they indicate the possibility of growing large yields of wheat of high quality under canal irrigation. At the Aligarh experiment station Dr. Parr, Deputy Director of Agriculture, United Provinces, obtained very high yields with one of the Pusa selections and has arranged for extended trials of this wheat in his circle during the next year. Arrangements for the trials of Pusa wheats next year have been made at Mirpurkhas in Sind and in the Punjab at Lyallpur and Gurdaspur.

A considerable demand for the new wheats has arisen from Australia in consequence of the satisfactory behaviour of the Indian samples grown there in 1909. In the same year a small sample of Pusa 6 was tried in Hungary with the result that 16 maunds of this variety were asked for by and supplied to the Minister of Agriculture of Austria-Hungary in April last.

One result of the wheat investigations, which is of considerable importance to India and to the future policy of the Agricultural Department, deserves special notice. This is the value of the variety of a crop when it stands alone. It is sometimes thought that in the case of crops improved varieties can be produced of such excellence that when distributed to cultivators greatly improved yields will result, no matter what the methods of cultivation adopted by the

people may be. A little consideration will show that these expectations are bound to result in disappointment as they entirely disregard the fact that two of the limiting factors in crop production in India are the methods of cultivation and moisture conservation adopted. Inadequate preparation for any crop and insufficient moisture cut across the real yielding power of varieties and tend to bring them to the same level. Optimum yields of the varieties and therefore true comparisons in yielding power are only possible if the limiting factors of bad cultivation and poor moisture conservation are removed. The full benefit of improved varieties, and especially those of high quality, can only be realised if cultivation is good and moisture is adequate. It is suggested that in all seed distribution schemes in India due attention should be paid to the prime importance of cultivation and moisture conservation as well as to the value of improved varieties. That it is possible to obtain greatly increased yields using only the means now possessed by the cultivators has been abundantly proved by the results obtained in the botanical area at Pusa during the last three years.

Trade Aspects.—Advantage was taken during the year of several opportunities of bringing the results of the wheat experiments to the notice both of the trade and of those interested in the cultivation of the crop. Everywhere the greatest surprise was expressed that wheats like those shown could be grown in India. In Karachi and Calcutta I ascertained from the leading wheat merchants that no difficulties are likely to be experienced by the growers in disposing (with considerable advantage to themselves) of uniform parcels of wheat of high quality. It is essential, however, that the quantities should be large and that the grades should be maintained from year to year. In Bombay a paper was read on the Pusa wheat experiments in the rooms of the Bombay Natural History Society, at which most of the wheat merchants attended, and at which an exhibit of the new wheats was shown. At the Allahabad Agricultural Conference I opened the discussion on wheat,

and as a result an extended trial of improved wheats and of improved methods of cultivation was arranged on some of the Court of Wards Estates. At the meeting of the Behar Planters' Association in February 1911 an account was given of the improved methods of wheat growing at Pusa which will be tried at a good many centres in Behar next year. Unfortunately, however, the demand for seed which arose after the meeting was far greater than the supply.

Milling and Baking Tests.—The most interesting point with regard to the milling and baking tests of Indian wheats during the past year is concerned with the quality of the new wheats raised at Pusa by hybridizing high yielding Indian wheats of poor quality (Muzaffernagar white and Punjab Type 9) with types of high grain quality but of lower yield. The results obtained show that the problem of combining high yield and high quality has been solved, the new wheats behaving in the mill and bakehouse like the high quality parent. A bulletin summing up the present position of this aspect of the subject and giving the results of 1910 in detail has been published. In response to numerous requests a full account of the actual methods adopted at Pusa in growing the crop has also been included. Translations in Urdu and Hindi of this paper have been prepared during the year by members of the staff.

Influence of the Environment on Quality.—The experiments on this subject which are being conducted in collaboration with Mr. H. Martin Leake, Economic Botanist to the Government of the United Provinces, were greatly extended during the year, and a large number of samples have been forwarded to England for complete milling and baking tests. It is expected that the results will confirm the opinion previously expressed that high quality and high yield both depend on proper cultivation and on proper soil management previous to sowing time.

Tobacco.—A considerable amount of progress has been obtained during the year in the tobacco experiments.

Manuring.—It has been found at Pusa that the success of this crop in Behar depends on the rapidity of growth during October and November, and that this rapid growth is only possible provided a large supply of organic manure in the right condition is added to the soil. It is usual to use indigo *seeth*, oilcake and cattle manure for this purpose, but the application of these substances in sufficient quantity is a costly process. In 1909 it was found that green manuring with *san*, if carried out in good time so as to allow of a thorough incorporation with the soil, was not only as effective as the organic manures usually employed but also far cheaper. During the present year the results were repeated, and trials of the same varieties with *seeth*, *san*, cattle manure and oilcake were made. Both in yield and quality of cured leaf the results with *san* were entirely satisfactory, and accordingly the Pusa results have been brought to the notice of planters interested in tobacco growing in Behar, and extensive trials with *san* are now being made in the district. As in wheat growing it has been found at Pusa that attention to the details of cultivation and moisture conservation are of the greatest importance in tobacco cultivation. About 34 maunds of cured leaf (omitting the lower portions of the stalk usually included in Behar) were obtained to the acre at Pusa last year—a yield greatly in excess of the crops in the neighbourhood.

Curing.—Results of considerable promise have been obtained in the curing experiments which are being conducted in collaboration with the Peninsular Tobacco Company at Monghyr. The varieties used were both American, and also the most promising of the Pusa selections, and the method adopted was a modification of that usually employed by the people. Under the conditions of the experiment the Indian tobacco gave better results than the American, and one of the Pusa selections gave leaf of considerable promise. The experiments are being continued on a large scale.

Breeding.—Both in *Nicotiana tabcum* and in *Nicotiana rustica* considerable progress has been made by the

Personal Assistant in the investigation of the inheritance of characters in this crop which, as was expected, has turned out to be a somewhat complex subject. The object of this work is to discover the mode of inheritance of the various leaf characters in particular so that new and improved varieties can be made by hybridization. Practically nothing is known on this subject, and the scientific breeding of tobacco is still in its infancy.

Fibres.—San (*Crotalaria juncea*, L.).—Several new varieties of this crop have been isolated during the year, and interesting results have been obtained with this crop as a green manure. These are being repeated during the next cold weather at Pusa.

Patwa (*Hibiscus Cannabinus*, L.).—A paper on this crop in India is now about to appear in which the work done during the past four years at Pusa is summed up. Natural cross-fertilization takes place in this crop to a considerable extent, but it has been found possible to eliminate to a great extent the effects of this by removing the hybrids during the seedling and vegetative stages. Possibly these methods can be extended to other Indian crops in which crossing takes place and can be made use of on seed farms.

Pollination.—The importance of a close study of the methods of pollination in the crops of India and the bearing of these matters on the growth of seed for distribution to the cultivators in India were dealt with in a memoir published during the year. This matter was referred to in the previous annual report. The paper in question has attracted a good deal of attention, and the subject has been developed still further during the year. Natural cross-fertilization has been found to occur in *til* (*Sesamum indicum*), *rahar* (*Cajanus indicus*), niger (*Guizotia Abyssinica*) and in Jute (*Corchorus capsularis*). Some progress was made during the year in working out the pollination details in the various oil-seed crops grown in India.

Programme of work for 1911-12.—1. *Training.*—The training of advanced students in this section will be continued.

2. *Plant Breeding and Plant Improvement.*—During 1911-12 the following crops will be studied:—wheat, tobacco, oil-seeds and fibre plants.

(*a*) *Wheat.*—The botanical survey of the wheats of Baluchistan and the agricultural survey of the wheats of Bengal will be completed. The production of improved and rust-resistant varieties by selection and hybridization will be continued. The co-operative experiments on the influence of the environment on the milling and baking qualities of Indian wheats which are being conducted in collaboration with Mr. H. Martin Leake, Economic Botanist to the Government of the United Provinces, will be continued on an extended basis.

(*b*) *Tobacco.*—The production of new varieties by selection and hybridization will be continued as well as the testing and curing of the varieties already isolated. The investigations on the influence of the environment on the stability of the type and quality will be continued.

(*c*) *Oil-seeds.*—The study of the oil-seeds of India will be continued on similar lines to those adopted in the investigations on wheat.

(*d*) *Fibres.*—The isolation and testing of pure races of the fibre plants of India will be continued.

(*e*) *Fruit.*—The fruit experiments at Pusa will be continued on the lines laid down in the First Fruit Report. During the months May to September, the work connected with the development of the fruit industry of Baluchistan will be commenced.

Publications.—The large amount of work that had to be got through during the past year has delayed the publication of results, but it is hoped this will be disposed of during the next year.

A fifth volume of *Die Züchtung der landwirtschaftlichen Kultur-Pflanzen* dealing with the breeding of tropical plants is now being published by Messrs. Paul Parey of Berlin under the editorship of Professor Dr. C. Fruwirth of Vienna. I accepted the invitation to contribute the articles on the following crops :—

Jute (*Corchorus capsularis* and *Corchorus olitorius*), *til* (*Sesamum indicum*), *patwa* (*Hibiscus cannabinus*), rozelle (*Hibiscus Sabdariffa*) and *san* (*Crotalaria juncea*), and papers on these have been forwarded to Vienna.

In addition the following papers have been published during the year :—

1. Suggestions for the Development of the Hop Industry of Kashmir. (Printed by the Kashmir State for official use.)
2. The Milling and Baking Qualities of Indian Wheats, No. 3. Some new Pusa Hybrids tested in 1910. Pusa Bulletin 22 (with G. L. C. Howard).
3. The Economic Significance of Natural Cross-fertilization in India. Memoirs of the Department of Agriculture of India (Botanical Series), Vol. III, No. 6 (with G. L. C. Howard and Abdur Rahman Khan).
4. Studies in Indian Fibre Plants, No. 2. On some new varieties of *Hibiscus cannabinus*, L., and *Hibiscus Sabdariffa*, L. Memoirs of the Department of Agriculture in India (Botanical Series), Vol. IV, No. 2 (with G. L. C. Howard).
5. Report on Economic Botany for the year ending June 30th, 1910. Printed in the Report of the Board of Scientific Advice, 1911.

REPORT OF THE IMPERIAL MYCOLOGIST FOR THE YEAR 1910-11.

(E. J. BUTLER, M.B., F.L.S.)

1. *Charge and Establishment.*—I remained in charge of the section throughout the year. Mr. F. J. F. Shaw held the post of Supernumerary Mycologist. Mr. J. F. Dastur was confirmed in his appointment as first assistant. Babu P. C. Kar was appointed to the vacant post of second clerk. All the staff have worked well.

2. *Training.*—Mr. F. Fateh-ud-din, Assistant Director of Agriculture, Punjab, attended for a mycological course once a week up to April 3rd. A forest ranger from the same province received a course of training in fruit diseases up to August 13th. A private student from Bombay abandoned the course early in the year. Amongst visitors Dr. Vermoesen, Mycologist elect to the Belgian Congo, worked in the Laboratory for over two months at the end of the year.

3. *Aid to Provincial Departments.*—Collections of named fungi, chiefly parasitic, have been supplied to the Madras and Mysore mycologists. A considerable number of specimens have been named for nearly all the provinces, the largest number being for Bombay and Eastern Bengal and Assam. Advice regarding the work of Provincial assistants has been given on several occasions.

4. *Plant disease investigations.* (*a*) *Palm diseases.*—A memoir giving a full account of the bud-rot of palmyra, coco and areca palms in Madras was published in September. An organised campaign, having as its object to prevent the spread of the disease and to stamp it out within the affected area in Godavari and Kistna Districts, has been in progress since 1907. The parasite (*Pythium palmivorum*) attacks the crown of the palm only, killing the tree by destroying the growing point. Spores capable of

spreading infection from tree to tree are liberated at an advanced stage of the disease. No other method of checking this infection was found practicable than burning the diseased tops before spores had time to form. This was carried out by gangs of toddy drawers recruited by a staff of subordinate officers of the Revenue Department under the control of a special Deputy Collector. Up to the end of the financial year 1910 about half a million palms had been cut out in Godavari at a cost of some Rs. 50,000. The operations were extended to Kistna in January, 1910. The conclusions given in the memoir are as follows:—"The operations have been entirely successful in limiting the disease in Godavari District to the area previously infected. Now that they have been extended into Kistna, it is fully trusted that they will be equally successful in checking the alarming spread to the south which has been going on for some time in that direction. This alone should fully justify the cost of the operations and their continuation. It is unfortunately impossible to estimate the number of trees saved from attack within the infected area. Still the number of trees saved in those parts where the work has been longest in progress must be many thousands, and apart from preventing any extension in the Godavari District, it is not unlikely that the value of the palms actually saved within the district already exceeds the cost of the operations." Since 1910 the control of the work has passed into the hands of the recently appointed Madras Mycologist, Mr. W. McRae.

(*b*) *Tea diseases.*—A bulletin by Mr. W. McRae, on the outbreak of blister blight of tea in Darjeeling District, was published in July. This contained a more complete account of the disease than the publications on the same subject mentioned in last year's report. It is unfortunately probable that the blight has come to stay in Darjeeling as it does not seem to have appreciably diminished since its first appearance. Many planters are experimenting on the lines suggested by Mr. McRae for its control, but it is evident that effective measures will be most difficult to carry

out. A tea parasite, *Laestadia Theae*, found in Java some 12 years ago but not previously recorded in India, was reported from the Dooars in July. It causes a leaf disease, known as copper-blight, which spreads with great rapidity, but appears to be closely dependent on weather conditions. A note describing its characters was written by Mr. F. J. F. Shaw for the January number of the Agricultural Journal of India. A disease of tea seed known for many years in Assam was investigated by the Imperial Mycologist in collaboration with the officers of the Scientific Department of the Indian Tea Association. It has been shown to be probably associated with the tea seed bug, *Poecilocoris latus*, which punctures the seed and sucks the juice. Through the opening thus made fungi are able to enter, and the subsequent injury to the seed is due to the growth of one or other of several species of rot-producing fungi at the expense of the seed tissues. The Tea Association is issuing a pamphlet pointing out that this insect is probably much more injurious in seed gardens than was previously suspected and recommending measures for its destruction. Several other tea diseases were investigated during the year, in particular the stem canker, the cause of which is still obscure.

(*c*) *Soft rot of ginger.*—Mr. W. McRae published an account of this disease in the Agricultural Journal of India, April, 1911. It is prevalent in Eastern Bengal, Gujarat, and probably elsewhere. In Rangpur the loss in damp soils is 10 to 15 per cent. of the crop; in bad years almost the whole may be lost. The cause appears to be the attack of a fungus (*Pythium gracile*) on the rhizomes and base of the plant. As a result of experiments carried out at Rangpur in 1908-09, Mr. McRae was in a position to recommend effective measures for checking the disease.

(*d*) *Turmeric leaf-spot.*—This is a disease found all over Northern India, but not usually very destructive. It was found by the Imperial Mycologist to be caused by an undescribed species of *Taphrina*, and an account of it was published in the Annales Mycologici in February, 1911.

It is probably responsible for a reduction of the yield which may be much greater than the cultivators themselves suspect, but no treatment can be recommended as yet.

(*e*) *Wilt diseases.*—Experiments carried out at Pusa and independently by the Mycological Assistant of the Bombay Department at Poona, have demonstrated that the fungus which causes *rahar* (pigeon pea) wilt produces virulent spores on the stem of diseased plants. Hence it is advisable to pull out attacked plants early. Mr. Shaw has found that the cause of the death of cotton seedlings at Cawnpore is *Rhizoctonia* and not a *Fusarium* wilt. It is probable, however, that the cotton disease in the Central Provinces, Berars and other parts of India is a true wilt, and it is hoped to investigate this shortly. A gram disease resembling wilt, sent from the neighbourhood of Peshawar, was found to be caused by *Ascochyta Pisi* and not *Fusarium*. A supposed outbreak of indigo wilt which caused a good deal of alarm in September, was shown to be due to leaf-sucking insects.

(*f*) *Sugarcane diseases.*—The field experiments with red rot and *Cephalosporium* disease were abandoned as the plots became infected throughout, and were also attacked by white-ants. Successful inoculations were obtained with a fungus which causes a root disease in Madras and has not previously been described. The Bombay Department is following the recommendations of this section in introducing healthy sets into some districts where red-rot is severe.

(*g*) *Forest tree diseases.*—These continue to occupy a certain amount of time as there is no Mycologist attached to the Forest Department. The chief work of the year was the study by A. Hafiz Khan of the passage from root to root below ground of *Trametes Pini*, the fungus which causes heart rot of the blue pine. He published an account of his investigation in the *Indian Forester*, October, 1910. A serious disease of the *Nahor* (*Mesua ferrea*) has appeared in Sibsagar and Tista Divisions. It is undoubtedly caused by a fungus at the base of the tree, but we have

failed to isolate the species. A leaf disease of Piauhyensis rubber reported from Assam was identified as *Cercospora Cearae*, which has not previously been recorded on this tree. Diseases of sal, Casuarina, babul pods and deodar were also examined for the Forest Department.

(*h*) *Root-rot caused by Rhizoctonia.*—In September of last year a number of crops on the Farm were attacked by a species of *Rhizoctonia*. The crops damaged were principally groundnut, cowpea and jute, at the same time specimens of cotton seedlings from Cawnpore showed similar symptoms of disease. The fungus was isolated from each host and cross inoculations performed with a view to ascertaining whether special races of the fungus are restricted to particular hosts and the extent to which crops are liable to infection in the field. Owing to the subsequent discovery of *Rhizoctonia* on the mulberry and papaw, the scope of the work has since become extended; at present, except in the case of the *Rhizoctonia* on jute, the evidence is against the existence of special physiological races on particular hosts. A fruiting stage of the fungus was discovered on the groundnut and coincides with one which has been previously described as occurring on potatoes in America.

(*i*) *Other plant diseases.*—A disease of wheat which does not appear to resemble any hitherto described, was reported from Dharwar and Hoshangabad. It is hoped to investigate it more fully next season. The anthracnose of chillies caused by *Colletotrichun nigrum* was widespread last year, and we had several enquiries about it. Other anthracnoses examined were those of beans, sida, mango and plantain. An attack of a species of *Phytophthora* on rhea was reported from Dacca. The study of the *Phytophthora* on castor was continued. The downy mildew of *Cucurbitaceae*, *Plasmopara cubensis*, was found at Pusa during the year. This disease, which has been spreading gradually throughout the temperate portions of the world during the past fifteen years from centres in the United States and Japan, was not previously known in India.

The conidial stage of the *Sclerospora* on jowar was found in Bombay and supports the conclusion previously arrived at that the disease is identical with that of bajra due to *Sclerospora graminicola*. The number of parcels of specimens sent in for examination was 97, and, as usual, a large part of the routine work of the section was the identification of these; recommendations for the check of diseases caused by them were given when possible.

5. *Systematic work.*—Much time was given to this branch of the work during the year. It has been pointed out in previous reports that the accumulation of a good classified collection of Indian fungi is as necessary a part of the equipment of the section as the microscopes or other tools of the laboratory. In India, unlike more advanced countries, we have nowhere to turn to to get this work done for us. It is true that we have received generous help from specialists in other countries, but to secure this we have to undertake our share of the work. Within the past few years a large body of the *Phycomycetes*, rusts and smuts of India have been determined. The *Ascomycetes* were taken up last year, and some hundreds of specimens worked through and sent to Berlin, where the determinations will be published in collaboration with Messrs. H. and P. Sydow. Two large groups, the *Basidiomycetes* and *Deuteromycetes*, remain to be worked out, but it will not be possible to undertake their study for some years. Considerable additions to our knowledge of Indian *Phycomycetes* and rusts were also made during the year. Over 600 sheets were added to the herbarium.

6. *Miscellaneous.*—Mr. Shaw assisted the Imperial Bacteriologist in investigations of eri silkworm diseases and tobacco wilt. Eight show-cases of typical fungus diseases of plants were exhibited at the Allahabad Exhibition. A teaching collection of fungi with notes was prepared for the Elphinstone College, Bombay. A report was written on the invasion of *lantana*, a noxious weed of Mysore and Coorg, and measures for its check recommended. The

proposals made in collaboration with the Imperial Entomologist, for the legislative control of plant imports likely to introduce injurious insects and fungi into India, were printed and circulated for the consideration of Local Governments and public bodies interested, and have met with, on the whole, a favourable reception. To carry these proposals into effect will be one of the most important duties of the section in the near future. A note on the organisation of the service for the control of insect pests and fungus diseases was drawn up, also in collaboration with the Imperial Entomologist, for the International Institute of Agriculture, Rome. An outbreak of flax dodder at Pusa was dealt with, the crop being burnt. Recommendations were made to the Scientific Department of the Indian Tea Association of the best means to adopt for disinfecting tea seed intended for export, as this was insisted on in the country for which the seed was intended.

7. *Programme of work for 1911-12.*—(1) *Research and Experimental work.*—The work on the wilt diseases of crops will be continued on the lines indicated in the memoir on Pigeon-pea wilt published last year.

The investigation of the fungus diseases of sugarcane will be continued. The chief points of the present enquiry are the spread of red-rot through the soil, the relative immunity of thin canes to this disease, and the study of two undescribed cane diseases.

The study of some fruit diseases commenced last year will be continued, particularly with reference to their control by spraying.

The Supernumerary Mycologist is engaged on an investigation of the root-rot of a number of crops caused by the fungus *Rhizoctonia solnri.* This will be continued.

(2) *Training.*—This will be continued on the lines indicated in the prospectus. Short courses will also be given to students taking the fruit growing and general courses and to private students, as during the past year.

(3) Advice regarding the fungus diseases of plants will continue to be given to other departments, particularly the

Provincial Departments of Agriculture and the Forest Department, and to the general public. The distribution of named specimens and other material to provincial colleges and other institutions will also be continued.

(4) The collection and identification of Indian parasitic fungi will be continued.

PUBLICATIONS.

The Bud-rot of Palms in India. E. J. Butler. Memoirs of the Department of Agriculture in India, Botanical Series, Vol. III, No. 5, September, 1910.

A new genus of the Uredinaceae. E. J. Butler. Annales Mycologici, Vol. VIII, No. 4, 1910.

The Leaf Spot of Turmeric (Taphrina maculans n. sp.). E. J. Butler. Annales Mycologici, Vol. IX, No. 1, 1911.

Report on the Outbreak of Blister Blight on Tea in the Darjeeling District in 1908-09. W. McRae. Bulletin No. 18, Agricultural Research Institute, Pusa, July, 1910.

Soft-rot of Ginger in the Rangpur District, Eastern Bengal. W. McRae. Agricultural Journal of India, Vol. VI, No. 2, April, 1911.

Copper Blight of Tea. F. J. F. Shaw. Agricultural Journal of India, Vol. VI, No. 1, January, 1911.

Root Infection of Trametes Pini. A. Hafiz Khan. Indian Forester, October, 1910.

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REPORT OF THE IMPERIAL ENTOMOLOGIST FOR THE YEAR 1910-11.

(T. Bainbrigge Fletcher, R.N., F.E.S., F.Z.S.)

Charge and Establishment.—Mr. Maxwell Lefroy, the Imperial Entomologist, held charge of the section until 30th January, when he proceeded on privilege leave and furlough out of India, the work of the section being then continued by me until the close of the period under review. There have been no changes in the permanent establishment during the year. Mr. C. S. Misra, the First Assistant, who was on privilege leave from the commencement of the year to 9th July 1910, had charge of the field-work on the Pusa Farm and Botanical Area and of the lac work, and has given two courses of instruction to students who attended for the short course in lac culture. Besides this, and apart from the personal instruction given by the Imperial Entomologist, Mr. Misra has had charge of the Laboratory and field training of the students in General Entomology; in this, as in his other work, he has done admirably. Mr. C. C. Ghosh, the Second Assistant, has been in charge of the insectary and has carried out extremely useful work in rearing and observation of insect pests. The Third Assistant, Mr. G. R. Dutt, has been in charge of the economic collections and records and has carried out the issue of coloured plates and lantern slides; in addition to his own heavy routine work, he has found time to study the Aculeate Hymenoptera and has prepared a Memoir on the life-history and habits of some of these insects. Mr. D. Nowrojee has been in charge of the general collections of insects and has done very good work in their upkeep and arrangement; this is work which naturally expands automatically every year, but Mr. Nowrojee has been able to do original work as well, and has written a Memoir on aquatic insects which is in the press at the date of this report.

He was away on privilege leave from 16th December 1910 to 6th January 1911. Mr. R. R. Ghose, who held the post of Sericulture Assistant, resigned on 25th October 1910, since when the position has been filled by Mr. M. N. De, who has worked hard and satisfactorily.

Visitors.—The Assistant Professor of Biology in the Punjab Government College, Lahore, and the Lecturer in Entomology at the Cawnpore Agricultural College, both worked in the Laboratory during their vacation periods, the former from December to January and the latter from March to June. The Entomological Assistant to the Baroda State spent a fortnight in Pusa discussing his work and his programme for the ensuing year and in collecting information likely to be of use. The Entomological Assistant, Burma, also spent about three months at Pusa, learning the practical side of Sericulture and obtaining information about crop-pests.

Training.—One student from the United Provinces remained from last year and continued his course in General Entomology until October. During the year, the newly-appointed Lecturer in Entomology at the Lyallpur Agricultural College and the Entomological Assistant in the North-West Frontier Province were received for the full course of training in Advanced Entomology, and will complete their course in December next. It is to be regretted that no students have been sent for the course commencing on 1st June 1911. The short courses in Sericulture were attended by many applicants from all parts of India, and of these thirteen have completed their course during the year; seven other students were received in June 1911, of whom six remain under instruction. The semi-annual short courses in Lac-culture have been taken up by fifteen students, of whom six were Forest Rangers specially deputed for this purpose. A certain amount of instruction in Bee-keeping has also been given to interested applicants, but as Apiculture in the Plains of India is still in an experimental stage, no regular course of instruction can be given before its success is assured.

Provincial Work.—The number of assistants employed in Entomological work in the Provincial Agricultural Departments is now seventeen, of whom six are engaged in teaching in the Agricultural Colleges and eleven in field-work, and of the above numbers two (one in each class) are still under training at Pusa. In view of the enormous areas to be dealt with and the general ignorance of the cultivating classes regarding insect pests and their control, this number appears very inadequate to place the practical side of Economic Entomology in its proper position as a normal part of agricultural practice, but the number of assistants is not being increased in the absence of Provincial Entomologists to direct their work. The fact that Economic Entomology forms part of the regular course in Agriculture at six of the Provincial Colleges must count for something in the spread of a knowledge of crop-pests amongst the agricultural classes. As in previous years, the assistance offered from Pusa in co-ordinating and checking the work of these assistants has been utilised by some provinces, who have referred the more technical work to Pusa, leaving the field-assistants free to undertake practical work and demonstrations.

In Madras, steady progress has been made in investigating the insect-pests of crops and in devising and demonstrating means of control applicable against each, and very good work has been done; this is the more important because the insect-pests of Madras are to a large extent different from those which occur in the plains of Northern India. In the Central Provinces, the experiments against Termites (white-ants) have been continued at Hoshangabad in collaboration with the Deputy Director of Agriculture, Northern Circle, and work against Potato Moth has also been continued. In the United Provinces, good work has been done in demonstration of methods against Cane Grasshopper and Potato Moth. In Bengal, very good work has been done in experiments and demonstration of methods of storing potatoes to keep them from Potato Moth, which is steadily spreading throughout the province. In Eastern

Bengal and Assam, the principal pests dealt with have been the Rice Grasshopper, Semiaquatic Rice Caterpillar and the Behar Hairy Caterpillar. In Baroda State, the Entomological Assistant has done good work in promoting an interest amongst cultivators in such pests as the Hairy Caterpillar, the Bollworm and the Til stem-borer and in inducing the adoption of measures against these and other pests.

Generally speaking, the Entomological work in the Provinces is at present preliminary and is necessarily confined to little more than inspection of the experimental farms, noting the local pests and the destruction caused by them and demonstrating methods to cultivators in the event of any special outbreak. Much more than this cannot be done whilst the Provincial Entomological staff is so limited.

Correspondence.—This is a subject which increases automatically every year as the work of this Department becomes more widely known. In addition to local inquiries as to insects attacking crops received and answered by the Provincial Agricultural Departments, a very large volume of correspondence is received and dealt with at Pusa; this includes a large amount of correspondence received from official sources, but a very large proportion is in reply to questions and requests for information and advice by the general public, and these include queries on almost every conceivable phase of Entomological work—insects damaging crops, gardens, orchards, timber, ornamental trees and shrubs, books and papers, stored cereals and produce of all kinds, insects on domestic animals, silk, lac, bee-keeping, insecticides and sprayers, and the identification of insects—and even on subjects not strictly concerned with insects, such as the destruction of rats. The parcels of injurious insects sent in numbered 166. A total of 2,384 inquiries came in from official and public sources, and the whole of these were dealt with as fully as possible. This is work which occupies a very large and constantly increasing proportion of time, but we consider that this work has a very direct value and that it is our duty to satisfy

every inquirer to the best of our ability. The large increase of clerical work during the year has thrown a great deal of additional work on the Clerk (S. C. Mukerji) and Typist (T. V. V. Subramani), both of whom have worked very satisfactorily and their work deserves special mention.

Research.—Progress has been made with inquiry into the life-histories and habits of injurious insects. Amongst the more important of these have been the Rhinoceros Beetle, the Surface and Painted Grasshoppers, Potato Bug, Lucerne *Hypera*, Small Cabbage Caterpillar, Termites, Rice Weevil, Green Bug, Potato Mealy Bug, Fish Insect and Red Pumpkin Beetle. Experiments have been made on the preservation of wood from attack by Termites (white-ants). Assistance has been afforded to the Imperial Agricultural Bacteriologist in furtherance of his work on the diseases of Eri Silkworms.

Insecticides and Sprayers.—A number of patent insecticides received for trial have been tested and reported on as to their suitability for Indian conditions; as a rule, they are not superior in efficacy to simple mixtures procurable locally, whilst their prices are prohibitive. Information on insecticides for Indian use has been collected in Bulletin No. 23. An increasing number of spraying machines is sold in India every year, and this Department keeps a register of the places where insecticides and spraying machines are obtainable, so that inquirers can be at once referred to the vendor supplying the kind suited to their needs.

Sericulture.—Experiments have been made on the crossing of Italian and French Univoltine Mulberry Silkworms with all the available indigenous multivoltine races, the object being to secure a robust and vigorous multivoltine race yielding a better silk than is produced by the native forms at present cultivated. Up to the present the mongrel races produced by crossing the European univoltine with Nistari and Burmese stock give the best promise as regards yield and quality of silk. Some of the

crosses between multivoltine indigenous races have also produced individuals more vigorous, more productive and less liable to disease than either parent stock. It will, however, require some time to establish a race which can be recommended.

Mulberry Silkworms from European seed were successfully reared at Pusa on bush mulberry in November 1910 and March 1911, the resulting thread having been valued by the trade in Calcutta at prices which compare extremely favourably with that obtainable from any multivoltine race. If it is possible to rear one (or, in many localities, two) broods of European worms on bush mulberry in Bengal and Eastern Bengal—and the Pusa experiments indicate no reason why this should not be done—the fact may have an important bearing on the silk trade.

The cultivation of Eri Silkworms has been continued at Pusa and is at present carried on in almost every district in India. The interest displayed in the cultivation of the Eri worm received a great stimulus through the display of Eri products at the Allahabad Exhibition, where a large building was entirely devoted to sericultural methods and manufactures collected and exhibited by this section. Here every process, from the egg to the finished cloth, was shown actually at work under practical conditions, and all kinds of silk cocoons, threads, cloths, etc., were also exhibited, a gold medal being awarded for these exhibits at the close of the Exhibition. An assistant from Pusa was in charge of the exhibits, and his time was fully occupied in explaining the processes and attending to innumerable inquiries from interested visitors, and particularly in bringing to their notice the advantages of Eri Silk and its cultivation in the provinces in localities where the climatic conditions and other factors are favourable to the adoption and extension of the industry. Batches of visitors—especially of the cultivating classes—were taken round and carefully shown the details of the work. A discussion was also held at the Agricultural Conference at Allahabad regarding the steps to be taken to extend the industry in the

United Provinces. Illustrated pamphlets, in English, Urdu and Hindi, describing the methods of rearing Eri and Mulberry worms, had been prepared at Pusa beforehand, and the real interest evoked by the exhibits could be gauged fairly accurately by the demand for these pamphlets and the large volume of further inquiries which has since come in to Pusa. Besides Allahabad, Mulberry and Eri worms, cocoons, thread, cloth, etc., and spinning and twisting machines in working order were shown at the local Agricultural Exhibitions at Muzafferpur, Bankipur, Malda, Banjetia, Singeswar and Calcutta.

Disease-free Eri and Mulberry silkworms' eggs, cocoons, thread, samples of Eri cloth, castor seed, mulberry cuttings and seed have been distributed to inquirers in all parts of India as far as possible. Trained rearers have also been sent to many places to teach Eri-culture to cultivators and others desirous of trying this product. Arrangements for sale of spinning machines have been continued, and at the request of the Imperial Entomologist, who pointed out what was required, a combined doubling and twisting machine, for doubling and twisting mulberry silk in one operation, was designed and produced by Mr. E. F. Watson and is now on sale. In extension of the work done here Eri silk-work was taken up by the Bengal Agricultural Department at Sabour from 1st April 1911, and it is hoped that the exhibition of this industry, within reach of the silk trade at Bhagalpur, will lead to the extension of the popularity and production of Eri Silk. Eri Silk has also been taken up by the Agricultural Department in the United Provinces, where Mr. Akhtar Mohammad Khan, Deputy Collector, has been deputed to conduct experiments at Shahjahanpur, and at Coimbatore by the Madras Agricultural Department. Successful attempts have been made to twist and dye Tussar Silk, but rearing of this has not been done at Pusa. In March 1911, at the request of the Director of Agriculture, I made a short tour in Eastern Bengal to investigate into the decline of the Mulberry silk trade and advise remedial measures; the result, which has

been reported already, cannot be summarized here. Eri thread of fine count has been produced on a commercial scale by the Chhoi Silk Mill Co. at Bombay, and the use of this fine thread should have an important influence on the development of the industry. There is still some difficulty in the disposal of small parcels of cocoons and thread by rearers on a small scale, the mills being unwilling to buy except in large quantities; a good deal of help in this direction has, however, been afforded by Calcutta firms who have been taking small parcels for shipment of the silk to Europe for experimental purposes.

Lac-culture.—Experimental work in lac-culture was continued, and brood-lac was supplied to applicants in Bengal, Central India, Madras and Bombay. Fifteen students were given a thorough practical training in lac-culture and numerous inquiries on this subject were also dealt with by correspondence. A continuation was made of the collection of material in collaboration with the Forest Department, with a view to the working out of the races of Lac Insects by Mr. E. Ernest Green, Ceylon Government Entomologist, 67 parcels containing 325 lots of specimens from a large number of food-plants having been received during the year. The material, as it accumulates, is sorted out with a view to facilitate the working out of the various races when the collection is completed.

Apiculture.—Two strains of specially selected Italian honey-bees were imported from England in November 1910, with a view to ascertaining their suitability to the conditions prevalent in the plains of India. The experiment has so far proved a success, but it is too early as yet to pronounce definitely on this.

Demonstration.—The most important item under this heading is probably the Allahabad Exhibition. Apart from the exhibits in the Silk House, 15 show-cases of insects injurious to crops and 24 cases showing the food of as many common Indian birds were prepared and exhibited in the Agricultural Court, 19 show-cases of Indian insects

were prepared for the Forestry Court, where this exhibit was awarded a gold medal, and, in the absence of the Second Imperial Entomologist, an exhibit of four show-cases was prepared for the Medical Court by the Supernumerary Entomologist to show the relations between insects and such diseases as Malaria, Enteric Fever, Plague, Myiasis, Cholera, Sandfly Fever, Yellow Fever, etc. I attended the Agricultural Conference held in January at the Allahabad Exhibition, and read a paper discussing practical remedies against two of the most destructive insects of the United Provinces.

Steady progress has been made in the preparation and issue of coloured plates illustrative of insect-pests of crops, and these have been distributed to all Provincial Agricultural Departments, to Museums, Agricultural Societies and numerous Educational Establishments. These plates are available for demonstration and for use in illustration of popular articles in vernacular and other Provincial journals. Show-cases were prepared and sent to the Dasehra Exhibition in Mysore. Coloured lantern slides of subjects selected from the coloured plates of crop-pests have been prepared and a large series of these is now available, besides series on Silk and Lac.

Insect Survey.—Comparatively very little time has been devoted to the general collections, but steady progress has been made, a large number of accessions having been added and arranged. Considerable additions have been made to the Students' Working Collections. Collections have been made up and sent out for identification by specialists and to authors of volumes in preparation for the *Fauna of India* Series: these include *Collembola*, *Orthoptera*, *Tettigidæ*, *Termitidæ*, *Neuroptera*, *Odonata*, *Braconidæ*, and *Ichneumonidæ Hymenoptera Aculeata*. *Dynastidæ*, *Rutelidæ* and *Cetoniadæ*, *Curculionidæ*, *Cleridæ*. *Microlepidoptera*, *Thysanoptera* and *Rhynchota*. Collections have been identified for Provincial Assistants, the Indian Museum, the Bombay Natural History Society's Museum, the Quetta Museum and for many private collectors.

Miscellaneous.—Exhibits illustrating the work of the section were sent to the International Congress of Entomology held at Brussels in August 1910. Entomological inquiries and notes sent in to the Bombay Natural History Society have been dealt with and the Imperial Entomologist lectured to the Society on the eve of his departure from India. Requests from officials and private persons outside of India for information, specimens, etc., have been complied with as far as possible. Live Eri cocoons have been sent to England, France and Morocco.

Programme of work for 1911-12.—The work of the past in advising on insects will be continued, and concurrently the study of the insect-pests of crops will be carried out in the Insectary at Pusa and by the Provincial Assistants. Assistance will be given, when desired, in co-ordinating and directing the Entomological work in the Provinces, and special help will be given in the event of any serious outbreak. The issue of coloured plates and lantern slides will be continued. The experimental work with bees will be continued and extended if possible. Instruction in Eri and Mulberry silk-culture and in the cultivation of Lac will be given to students attending short courses in these subjects. Further collections will be made of lac insects in all stages for the purpose of ascertaining the relationships of the various races. New insecticides and apparatus submitted for trial will be tested with a view to their utility under Indian conditions. Rearing of Eri Silk-worms will be continued and all possible help given to those commencing this industry. Further experimental work will be done on the mongrelisation of the races of the Mulberry Silk-worm, and it is anticipated that the provision of cold-storage at Pusa will much facilitate this. Special attention will be devoted to acquiring a knowledge of Indian Termites (white-ants), the damage they do, and the best methods of preserving crops and constructional material from their ravages.

Publications.—A list of the more important of these is attached, but less and less time is available for work of this

nature as the energies of the staff become more fully occupied in other directions; and this is the more regrettable because a large amount of information relative to the life-histories of many economically important insects has been gathered during the last few years. Amongst the publications now in hand or proposed to be written, and for which a large amount of material is now ready, are practical manuals on lac culture and bee-keeping, Memoirs on life histories of *Orthoptera*, *Hymenoptera*, *Coleoptera*, *Lepidoptera* and *Rhynchota*, a Memoir on Termites, a revision of *Indian Insect Pests*, a revision of *Insects injurious to Indian Agriculture*, and separate manuals on insects injurious to Fruit-trees, Garden-crops and Grains, etc.

Eri Silk as a Cottage Industry. (Pamphlet in English, Urdu and Hindi.) December, 1910.

Mulberry Silk in the United Provinces. (Pamphlet in English, Urdu and Hindi.) December, 1910.

Commercial Possibilities of Eri Silk. C. C. Ghosh (Indian Industrial Conference). December, 1910.

List of Injurious Indian Insects. April, 1911.

List of Insects in Pusa Collection. December, 1910.

Life-histories of Aquatic Insects. D. Nowrojee. (Memoir in the press.)

Food of Birds in India. C. W. Mason. (Memoir in the press.)

Palm Beetles. C. C. Ghosh. (Memoir in the press.)

Life-history of *Crocesfilipennis*. C. C. Ghosh. (Bombay Journal.) October, 1910.

Hairy Caterpillars in South Arcot. Y. Ramachandra Rao. (Agri. Journal, July, 1910.)

Entomological Demonstration in Baroda. C. U. Patel. (Agri. Journal, October, 1910.)

Two Insect Pests of United Provinces. T. Bainbrigge Fletcher. (Agri. Journal, April, 1911.)

Four Reviews in Agricultural Journal and one in Bombay Natural History Society's Journal.

Insecticides. H. Maxwell-Lefroy. (Bulletin No. 23.) August, 1911.

Eri Silk. H. Maxwell-Lefroy and C. C. Ghosh. (Memoir in the press.)

The Moth-Borer (*Chilo simplex*) by T. Bainbrigge Fletcher, (Pamphlet in English.)

REPORT OF THE SECOND IMPERIAL ENTOMOLOGIST FOR THE YEAR 1910-11.

(F. M. HOWLETT, B.A.)

In 1909, after a year and nine months' service, I was absent on sick leave for a year and five months, returning to Pusa on March 22nd last. I have, therefore, now just completed two years of active service, and the present is a convenient opportunity for putting forward one or two conclusions regarding the work of my section.

I was appointed to study Diptera, and in particular those insects which suck blood and which may transmit disease.

Roughly speaking the study of any group of insects usually takes one or two distinct but complementary lines :—

(1) *Taxonomics.*—The study of the structure of dead specimens as a means of obtaining an accurate nomenclature and scheme of classification, thereby facilitating the correlation of results obtained by work in other branches.

(2) *Bionomics.*—The study of the life-history, from egg to adult, and the habits of living insects, their relations with other organisms and the factors which determine their various activities as a means of obtaining knowledge which will enable us to control these activities.

Of these, (1) can be undertaken in any country to which specimens can be sent, and at any place affording sufficient facilities in the way of necessary literature. In this country the Indian Museum is the only institution at present possessing a library with any pretensions to adequacy in respect of Dipterous taxonomics; (2) can be undertaken only on the spot. The elucidation of the life-history and reactions of insects is the only way whereby we can attain to more than an empirical knowledge of how to control them. To follow this line in the case of a group such as Diptera, about which so little is yet known, demands moreover a

somewhat broader scientific outlook than is necessary to the pure systematist.

It would of course be possible to pursue taxonomic studies and occupy ourselves with the description and naming of new species of Diptera, useful work which might well be extended over several years, but this would, in my view, constitute under the circumstances a misdirection of energy, since such work can be better and more easily done elsewhere.

On these and other grounds I have regarded (2) as the direction in which our work should proceed, and I have now a foundation in a knowledge of the main features in the life-history and habits of all groups of blood-sucking insects in India, as also of the few Diptera which are of any considerable direct agricultural importance. I make use advisedly of the phrase "main features," since the present arrangements regarding laboratory accommodation do not admit of insects being kept alive except under conditions so unsuitable as often to make it difficult or impossible to obtain reliable results from observation of individuals in captivity. Our disabilities in this direction are serious, but I am glad to say that steps are now being taken towards the provision of more suitable accommodation.

I returned from England in March, arriving at Bombay on the 10th and at Pusa on the 22nd. No touring has been undertaken since that date. I found that since my departure an amount of material has accumulated which has occupied a good deal of my attention and which will take time to arrange and work out. A portion of our Nemocera has been named by Mr. Brunetti at the Indian Museum, and the identifications of a number of the Tabanidæ sent to the British Museum in 1908 have now been published, which will facilitate work in this group.

I do not here attempt to submit a detailed report of the past four months. In addition to work on the collection and on blood-insects in general, attention has been directed in particular to (1) parasites of Tabanidæ, mainly observations

on an egg-parasite of our common hot weather Tabanus (*T. albimedius*); (2) temperature reactions of Mosquitos; I believe I have found that temperature constitutes at least one of the main factors controlling mosquito-bite; more observations are required, and the work is still in progress; (3) the relative efficiency of "millions" and other enemies of mosquito-larvæ, in progress; (4) Peach-flies; with regard to these last it seems improbable that their attacks can be completely prevented by anything short of netting the trees, but we have now a cheap and simple method (depending on the "chemico-sexual" reactions of the male flies) whereby the damage they do may be very much reduced.

A number of publications are in hand. Four students have been received, though it was impossible to allot them any window-space in which to work.

While absent on sick leave, I attended the First International Congress of Entomology at Brussels, and though unable to enjoy the lavish hospitality which was displayed by the Congress Officials towards all visiting delegates, I was present at all the meetings and read two papers, by Mr. Lefroy and myself. These will be published in the Proceedings of the Congress. From the scientific point of view, the Congress was most successful, the great majority of the papers read being of a high standard of excellence, and I cannot overestimate the value of this opportunity of getting into touch with recent work, and of meeting and exchanging views with Entomologists of other countries.

In connection with a plague of house-flies near Norwich I carried out (in collaboration with Dr. Copeman, F.R.S., Medical Inspector to the Local Government Board, and Mr. Merriman) what I believe to be the first successful series of experiments on the range and rate of flight of these insects under natural conditions, a point of considerable importance with regard to disease-transmission. The results are published in "New Series No. 53 of the Local Government Board Reports on Public Health and Medical Subjects."

Prior to sailing for India I spent five weeks in Cambridge, working in Professor Nuttall's laboratory on the

respiratory mechanism of Ticks and the influence of temperature on rat-fleas; I may remark that the temperature which was fatal to adult fleas was found to be unexpectedly low. I also prepared several illustrations for Professor Nuttall, made an experimental study of the effects of various degrees of magnification and reduction in reproducing drawings and wrote two articles [on (1) Mosquitos and Temperature, (2) Methods of preserving Insects] which were published in "Parasitology."

Programme of work for 1911-12.—Work on blood-sucking insects, ticks, and other similar parasites directly or indirectly injurious to man will be continued, and attention will also be given to Dipterous pests of crops and fruit. Instruction will be given to agricultural students in these subjects.

A large amount of time will have to be given to working through and arranging the material which has accumulated during my absence, sent in by Medical and Veterinary Officers.

Special investigations proposed are :—

(1) Life-history and habits of Simulium (hill cattle-fly), the dung-infesting Cattle-flies, Sand-flies, and such house-flies as are likely to be found acting as carriers of intestinal diseases.

(2) Bionomics of Mosquitos, with special reference to the influence of temperature.

(3) Influence of external conditions on the life-history of Fleas.

(4) Reaction of Diptera to chemical stimuli.

REPORT OF THE IMPERIAL BACTERIOLOGIST FOR THE YEAR 1910-11.

(C. M. HUTCHINSON, B.A.)

The work of the Bacteriological Section during the past year, the first during which it has been in operation, has necessarily been largely confined to trial and selection of the methods best adapted for dealing with the special conditions of soil and climate obtaining in India. The biological analysis of a soil not only involves a determination of the number and kinds of bacteria contained in it and their relation to the production of plant food, but must also include investigations having for their aim the discovery of how such bacterial functions as make for fertility may be encouraged and used to the best advantage in the ordinary operations of agricultural practice. Hence the main lines of work of this section have been aimed at determining under what conditions various soils will best serve as culture media for those bacteria, naturally present in them, upon which the processes of conversion of the organic nitrogen of humus into assimilable nitrates depend.

Much preliminary work has been done in testing methods already in use, and modifying them in accordance with the requirements of local conditions.

Special attention has been paid to methods of plating soils in such a way as to obtain information as to the number, kinds, and functions of the bacteria in them; this has involved a study of media suitable for the purpose, and of methods of inoculation, and this study is still in progress, as it appears probable that each soil requires variation in the composition of the medium in which it is to be plated, in accordance with its chemical and physical character, and with special regard to its previous agricultural history. In soil plates made for the purpose of counting the numbers of bacteria present per unit volume or unit weight,

special attention must be paid to the variations in soil climate previous to the time of sampling, as otherwise erroneous conclusions may be drawn as to the number of bacteria normally present. For instance, a rainfall of one-tenth of an inch in December has been found to raise the number of bacteria to 100 millions per gram in the course of 36 hours, whereas the same soil contained only 5 millions per gram two weeks later. Similarly the rate of decomposition and nitrification of organic matter in Indian soils appears to be very different from that which has been observed in Europe, and is no doubt to be correlated with the special conditions of soil and climate of this country. These cases have been referred to as illustrations of the necessity for proceeding with great caution in working out special problems by the application of generally accepted methods.

A complete series of experiments has been carried out to determine the best means of sterilizing soils, as the majority of experiments on soil bacteriology depend upon work with sterile soil as a medium. Great difficulty has been experienced in obtaining completely sterile soil; intermittent steaming in many cases has failed to ensure sterility, possibly owing to the rapid formation and germination of spores by some of the numerous spore formers present, and the use of the autoclave for pots of soil, of which only one can be inserted at a time, makes an experiment involving the use of some 50 pots almost impracticable, owing to the differences in time involved. A sterilizing plant for dealing with a large number of pots simultaneously is very much needed.

Samples of Pusa soils have been analysed bacteriologically, pure cultures of the bacteria found have been made, and their physiological functions examined. Special attention has been paid to their relative ammonifying power, and the knowledge thus obtained is now being utilized in dealing with special problems.

A special study has been made of the effect of hot weather ploughing upon the bacterial content of the soil and

its possible relation to the undoubted increase in fertility resulting therefrom. It has been found that this operation increases the rate of ammonification of the soil humus, probably by the selective action of combined desiccation and abnormal temperature; similar results can be obtained by heating the soil to 60° C., the soil plates shewing a survival of the more active ammonifiers such as B. Mycoides and B. Subtilis, whilst the highly aerated condition of the soil inhibits the activity of surviving anærobic spore formers. The net result is an extremely rapid formation of ammonia, part of which is retained by the soil and nitrified or taken up directly by plants, and part is lost by diffusion; in this way rapid depletion of the soil nitrogen must take place, and subsequent fertility will depend upon the judicious use of green manures; the economic value of the method depends upon the power which it places in the hands of the agriculturist of rapidly converting green manure or other organic nitrogen into plant food, although this may be counterbalanced to some extent by loss of nitrogen as ammonia.

Study of Pusa soil taken from depths down to nine feet shows large numbers of bacteria even at this low level; nitrification has been found actively proceeding in the third foot from the surface, the greatest amount of this taking place in the second six inches. Owing to the open texture of this soil it is improbable that denitrification occurs to any appreciable extent, but the rapid rate of ammonification and the vigorous growth of soil bacteria no doubt interfere with the production of nitrates.

A method of quantitative estimation of the changes in soil due to bacterial action, by periodical analysis of the soil gases, has given much information as to the conditions favourable for nitrification in soils; it is hoped that this method will be invaluable in the future for dealing with such problems as arise out of soil irrigation and drainage, and the use of green manures.

In connection with the experiments upon soil sterilization as a laboratory method, investigations have been car-

ried out to determine the effect of various methods of partial or complete sterilization upon fertility; these investigations are still in progress and have yielded some results of great interest, such as the fact that the addition of Toluene to a soil already sterilized by heat increases its suitability as a medium for the growth of ammonifying bacteria and consequently its fertility; this renders it unnecessary to assume that such action is due to the suppression of phagocytes, although there is of course no reason why such removal should not contribute to the general effect in soils partially sterilized by addition of Toluene.

So far but little work has been done upon any but local soils, as these have afforded ample opportunity for research, but samples of *Usar* soil have been examined in connection with the use of gypsum, cattle manure, and straw as means of modifying their infertile condition. Dr. Leather kindly supplied samples of these soils, and also some black cotton, Shillong, Bangalore, and Akola soils, which have been used for purposes of comparison with Pusa soils.

A circular letter was addressed to Directors of Agriculture and Principals of Agricultural Colleges in the Provinces with a view to eliciting their opinions as to the scope for bacteriological work on soils, and the existence of special problems of local interest suitable for investigation by this section. The replies were of great interest as shewing the very general realization of the value of such work, and many useful suggestions as to lines of enquiry were received. The opinion was expressed in several quarters that the training of assistants as soil bacteriologists who would be capable of dealing with local problems in the Provinces, should be an important item in the work of this section at Pusa. This is a point of view with which I am in complete agreement and I wish to express my opinion that the work done during the past year has shown the necessity for training in the use of the special laboratory methods which are necessary in India, and that such assistants as may be selected for work on soil bacteriology in the provinces

should undergo a preliminary training at Pusa. It is important that these men should have a previous training in analytical chemistry of a high order, as my experience has been that it is possible to teach bacteriology to a chemist, but that the converse alternative is a waste of time. This was my own experience at Pusa with a medically-trained bacteriologist who acted for a time as my assistant, and whose qualifications as a biologist did not fit him for work as a soil bacteriologist, this being due to the very different nature of the work involved in medical and soil bacteriology. On the other hand my present three assistants who are all chemists, have shown great aptitude for bacteriological work, and their previous training as analysts has been invaluable in dealing with soil problems, which depend largely for their solution upon quantitative estimation of chemical changes in soil constituents.

Certain special problems have been dealt with during the year; these include investigations of the cause of :—

1. A bacterial disease of Tobacco occurring in Rangpur, due to the presence of a strain of Bacillus Solanacearum, differing from those described in America and Japan in its pathogenicity both for Tobacco and other Solanaceous plants, such as Tomato and Brinjal (Solanum Melongena).
2. A disease of the *Eri* silkworm associated with the presence of bacteria in the intestine; Memoirs on these two subjects are in hand. Invaluable assistance in the preparation of sections for microscopic examination in connectios with these diseases was afforded by Mr. Shaw of the Mycological Section, who was kindly permitted by the Imperial Mycologist to devote a considerable amount of time to this work.
3. The efficacy of Ratin and Trope Ratin as rat exterminators in India. Experiments were made with fresh samples received from England, and a report on the results was furnished to the Inspector General of Agriculture in India.

Ratin is a bacterial culture prepared in Copenhagen, which is intended to produce an infectious disease in rats which have fed on baits treated with it, and which then spread the contagion amongst others. Although the cultures when received at Pusa were alive, as was proved by transfers, no pathogenic effects followed when given with food to captive rats. In corresponding with the Director of the Ratin Laboratory at Copenhagen I suggested that the virulence of the cultures might be regained by cultural methods in India.

Trope Ratin is not a bacterial culture but a vegetable poison, the principal feature of which is its toxicity for rats and mice and harmlessness for other animals. Experiments proved that its efficacy in India depends upon its use within a limited period of time after its preparation, as rapid deterioration takes place with loss of toxicity. Its cost precludes any possibility of use on a large scale by cultivators, but might allow of employment in special cases, such as in granaries or warehouses.

4. A disease of *Tussar* silkworms at Chaibassa was investigated and a report submitted to the Director of Agriculture in Bengal. The general conclusion arrived at was that death was due to bacterial invasion of the alimentary canal, but that as the extent to which this developed was dependent on unsuitable diet consequent principally on climatic causes, it would be impracticable to apply preventive or remedial measures.

5. A scheme for bacteriological work in connection with the proposed dairy at Pusa was elaborated, including the idea of a course of training for students in Bacteriology as applied to dairy work.

Programme of work for 1911-12.—1. The systematic investigation of the distribution, physiological character, and functions of soil bacteria in India will be continued.

2. A special line of enquiry will be taken up as to the relations existing between the practice of green manuring in India and the activities of soil bacteria.

3. Special problems, such as plant diseases of bacterial origin, will be dealt with as occasion may arise and opportunity permit.

4. The training of the assistants in the section will be continued.

Publication.—An article on the influence of Bacteria upon soil fertility was published in the Agricultural Journal of India, Vol. VI, Part II, April 1911.

REPORT OF THE IMPERIAL COTTON SPECIALIST FOR THE YEAR 1910-11.

(G. A. GAMMIE, F.L.S.)

I held charge of the appointment from the 1st July to the 5th August 1910, when I proceeded on privilege leave. During my absence, Mr. S. V. Shevade, B.Sc., held current charge of my office. I resumed my duties on my return on the 6th November and continued in charge until the end of the year under report.

In July, Londa, Dharwar Experimental Station, Gokak Experimental Station and Vadgaon (all in the Bombay Presidency) were visited. In the months of August and September, Mr. Shevade visited Vadgaon, Dharwar, Gadag, Kilgiri and Kumbarganvi. After my return from leave, I visited Vadgaon and made a tour in the Central Provinces in the company of the respective Deputy Directors. Khandwa, Raipur, Nagpur and Akola were visited. In November, I also visited Dhulia and Ahmednagar. In December, I again went to Vadgaon in connection with a scheme to introduce cotton into this tract, and in January I visited Khanapur, Londa, Belgaum and Desur with the same object. In the same month I saw the cotton-experiments at Sholapur. In February, I completed my observations on cotton growing in the Deccan, at Takari and Islampur and joined the Deputy Director on tour in Gujarat, visiting Navsari, Surat and Nadiad. In March, I met the Deputy Director of Agriculture, Bengal, to advise him regarding the prospects of cotton cultivation at Chinsurah. I again visited the Experimental Stations in the Southern Mahratta Country. For the remainder of the period I was engaged in laying down a series of trials in my experimental station at Kirkee.

Central Provinces Cottons.

I visited the Experimental Station at Khandwa, where I met Mr. Evans, the Deputy Director of the Northern Division. This station is 13 acres in extent and is divided into ½ acre plots, seven of which are devoted to cotton and five to *Jowar* and *Bajri* varieties. The experiments on cotton will be continued this year, taking in, however, only four varieties, *malvensis*, *roseum*, *Saugor Jari*, *Bhuri* and, perhaps, *Cambodia*. The following are the notes I drew out on the ground during my inspection :—

Karkeli.—This being *Hinganghat* (*Bani*) is not suited to this tract, and the fact is sufficiently proved by the appearance of the plot this season.

Malvensis is strong and vigorous and the outturn promises to be satisfactory. The staple, almost as harsh as, is longer than that of *roseum*. Which of the two will ultimately prove to be the most profitable is a point only to be determined by a test of outturn per acre. Local opinion strongly inclines to the belief that *roseum* is the more remunerative crop. This year *roseum*, being on a high-lying plot with shallow soil, cannot safely be compared for outturn with *malvensis*, which is on a lower level with deeper and richer soil.

Saugor Jari had borne its ripe bolls intact for about a month, and the White Flowered Varhadi or *roseum* also retained its ripe cotton uncommonly well. Practically none had yet fallen to the ground. The retention of the ripe cotton in the open bolls is a characteristic general to our indigenous Indian cottons.

Of *Bhuri* and *Cambodia* it can be safely said that the former is almost certain to succeed in the better classes of soil in this district. The group of cultivators, who accompanied us in the fields, concurred in my view after inspecting the crop as it stood on the ground.

Cambodia does not promise so well in the northern as in the southern cotton districts. However, to make the mat-

ter certain, it would be quite worth while to give it another year's chance.

Saugor Jari is a dwarf variety, coming so quickly to maturity that the first picking is ready this year in the middle of October. The seed was originally brought from the Rehli Taluka of the Saugor District. It is an extremely prolific cropper and appears to be suitable more especially for the poorer classes of soils, which are apt to lose moisture rapidly when the late monsoon fails as it often does in this district.

The seed obtained locally in Burhanpur has produced a crop so mixed (the mixture consisting of *Jari* with a smaller proportion of *Bani* and Upland Georgian) that the fact strengthens our conviction that, if pure varieties are established by the Department, which will then distribute them for general cultivation, methods must decidedly be devised, by home or village ginning or otherwise, to ensure that these varieties are maintained in their purity. As regards the establishment of this particular Experimental Station I foresee with satisfaction, that, being by its very nature a demonstration on an actual cultivator's land with the implements and labour supplied from his stock, the results will be readily visible to him and his neighbours.

In Berar and the Central Provinces, where cotton is usually grown associated with *Tur* (*Cajanus indicus*) more attention could be profitably paid to the cleanliness of the fields, which are infested with coarse grasses, *Celosia argentea* and other weeds.

I visited the Experimental Stations at Raipur, Nagpur and Akola in the company of Mr. Clouston, the Deputy Director, and Mr. Graham, the Economic Botanist.

At Raipur, which is beyond the cotton tracts, two plots were devoted to *Bhuri* and *Cambodia* cottons. The former gave a good crop last year and promised well for this. The Rajnandgaon Mill bought the produce at a fair price and the Manager is anxious to see the increased cultivation of this variety. It suffers from boll-worm, however, and the

general conditions of the district do not seem to be altogether favourable.

Cambodia looks unthrifty and chances are decidedly in its disfavour, but I advised Mr. Clouston to give it another trial as the rains have been abnormally heavy. Attempts to introduce the cultivation of *Deshi* cotton and *Jowar* have resulted in failure.

At Rajnandgaon we visited two fields of *Bhuri* in the company of Mr. Fredericson, the Manager of the local mill. These had done very well and the local cultivators were impressed with the result. Mr. Fredericson, however, says that *Bhuri* will not altogether serve as a substitute for American Upland, which is superior in quality. It will compete on favourable terms with the longer stapled indigenous varieties such as *Broach*, and this, after all, is a *desideratum* in the Central Provinces.

At Nagpur, Mr. Clouston still retains his plots sown from seeds locally obtained from many parts of the province and these have enabled him to gauge the nature and extent of the mixtures as they normally exist in the fields. Various high-class Uplands from American seed do not hold out promise of success. The utility of protecting cotton fields against insect attacks with girdles of *Bhendi* still seems to be a moot point, but, from my own experience, I cannot help considering that there is much to be said in its favour. Insects certainly prefer it to cotton, and if care be exercised in its destruction when its purpose is effected, much latent and active insect life must be destroyed at the same time.

The varieties of cotton actually under serious trial consist of *Bhuri*, *malvensis*, *vera*, *cutchica* and *rosea*.

In order of their value in length of staple they would stand thus :—(excluding *Bhuri*), *malvensis*, *vera*, *rosea* and *cutchica*. The last two are white-flowered forms of the two preceding them. *Malvensis* and *vera* (yellow-flowered forms) are decidedly superior in the matter of staple, but they are surpassed in percentage and total yield by *rosea* and *cutchica* (white-flowered forms). The valuations given

by the trade are practically equal for all, so, from a cultivator's point of view, the two last can safely be taken as the best to grow. Mr. Clouston estimates that he has gained from 2 to 3 per cent. in quantity by selection, and I seized the opportunity to point out to him that this is really a long step in advance, especially when it becomes established over the enormous cotton tracts of the Central Provinces and Berar.

The popular belief is that, by scientific methods, an increase in length of staple and proportion of cotton to seed can be easily attained, but the public generally and members of the Agricultural Department also should hold steadily in their view the fact that to evolve an addition of even one or two per cent. in length of staple and percentage of cotton to seed in a few years is in itself a notable feat, and that it is chimerical perhaps to hope to reach anything better. Anyhow, it would at least serve as an excellent foundation for a fresh start in advance.

Forms of all varieties with narrow-lobed leaves are more easily fixed than those with broad lobes. Undue importance should not, however, be attached to the degree of division in the leaves. At the Telinkheri farm there are plots of *Bhuri*, *Cambodia* and the indigenous varieties. All have suffered, although slightly so, from water-logging during the recent heavy rains. Cotton is a crop with a decided predilection for a well-drained soil.

The Department of these provinces is quite alive to the danger of the possibility of the reputation of their selected seed being ruined by the addition of local bazar seed by unscrupulous dealers for the sake of a temporary profit. It is difficult to conceive how such a contingency can be met in the case of indigenous varieties in which the seeds do not differ materially.

Cambodia, in all cases, seems to be inferior in strength and quality of produce to *Bhuri* in the Central Provinces and Berar, and it is also about three weeks longer in arriving at maturity, an objection of vital importance in these short season tracts.

At Akola, where a large area of the Experimental Station is devoted to the raising of selected seed, the cottons comprise *Bhuri*, *malvensis*, *vera*, *rosea*, *cutchica* and *Bani*. *Bani* has fallen into disrepute and one seed farm at Risod, especially devoted to producing its seed, has great difficulty in disposing of it. *Bhuri* seed is in rapidly increasing demand as are also *malvensis* and *rosea*, but the last-named, from its productiveness and hardiness, appeals most strongly to the cultivator. The manurial experiments appear so far to prove that farmyard manure has a distinct effect, but, that on account of their cost and trifling action there is little or practically no advantage gained from the use of artificial fertilizers. Farmyard manure and urine earth mixed give a better result than either applied alone.

All the varieties of cotton are pure now, and the chief difficulty ahead lies in the maintenance of this purity in the cultivator's fields. An accidental admixture of varieties on this station arose from the fact that whole seed was fed to the cattle and this often germinated in the manure when spread on the fields. Crushing the seed, of course, has removed this defect.

Experiments with English and indigenous ploughs and with the *Bhakar* go to prove that ploughing tends to assist water-logging in a wet season when the *Bhakar* is most effectual, but the latter method fails in a season of drought. As the cultivator can only guess what the season is going to be this conclusion is not obviously helpful. It appears to be advantageous to follow the local practice of sowing cotton in anticipation of the setting-in of the rains, and the converse applies to *Jowar*, which suffers badly if dry weather supervenes after germination.

In 1910, there were 3,000 acres of *Bhuri* under cultivation in Berar. Unfortunately the epidemic of plague greatly retarded its preparation for the market. The area actually under seed farm of all varieties is 600 acres. Three varieties of seed are supplied on purchase from this farm, namely, *malvensis*, *rosea* and *Bhuri*. At Risod in the

Hinganghat tract *Bani* is grown for distribution, but there is no call for the seed as the people are introducing the coarser, hardier and more productive *Jari* (vera) and *Varhadi* (rosea). An efficient hand gin of moderate cost and simple construction which would clean an appreciable amount of cotton per working day is an urgent necessity in the cotton tracts.

I wish here to emphasize my opinion that a real advance in the improvement of some of the staple cottons of the Central Provinces and Berar has already been effected. The cultivators show a practical appreciation of the fact by cheerfully paying enhanced rates for the selected seed supplied by the experimental stations. The chief difficulty in the future will be to maintain the varieties sufficiently pure. For some years to come the difficulty must either be met by large extensions of seed farms or by special arrangements with reliable cultivators either of villages collectively or as individual persons. At the same time steps should be taken to ensure that the cultivators receive fair rates for their improved produce.

It seems, however, too hopeful to look forward to the time when the people will realize the advantages of clean cultivation and cleanly methods of harvesting and marketing.

The British Cotton Growing Association sent the following gratifying account of the season's cottons grown at Akola :—

Value of Middling American 8·07d.

No. 1. *Bhuri.*—"Fully good middling" in grade. Staple about 1 inch. Strong. Value 7·90*d.* to 8·00*d.*

No. 2. *Bani.*—"Fully good middling" in grade. Staple about 1⅛ inch. Fine, but little soft. Value 8·40*d.*

No. 3. *Malvensis.*—"Fully good middling" in grade, little stained. Staple 1 to 1⅛ inch, irreguiar and rather soft. Value 8·20*d.*

No. 4. *Roseum.*—"Fully good middling" in grade. Staple rough and extremely short. Value 7*d.*, quite nominal.

It is mentioned that "with the exception of the fourth sample, *Roseum*, all the samples sent are useful cottons which could be readily sold in this market at considerably higher prices than are obtained from East Indian cotton, and we hope that there may be some possibility of these cottons being produced in quantity in your district."

Bombay Cottons.

Trial with Bhuri cotton at Kumbarganvi (12 miles from Dharwar).—In March 1909, while discussing cotton matters with the Deputy Director of Agriculture at Dharwar, I suggested the possibility of a successful introduction of *Bhuri* into the tract lying in the heavy rainfall zone where land was largely left uncultivated. Accordingly a plot of about 3 acres was taken up at Kumbarganvi. The soil is shaly, and is known in local Kanarese as *Masari*, *Bhurkati* or *Revti* in Marathi and *Gorat* in Gujerati.

The average annual rainfall is 50 to 60 inches, falling heavily from June to the end of September and more lightly till the beginning of November.

Two ploughings and three harrowings were given but no manure. The seed (obtained in 1908 from Bengal) was sown by drill at the rate of 20 lbs. per acre on the 18th August 1909. Germination was excellent and the plants were thinned out to a foot apart in the rows, which were at 2 feet intervals. The plants were soon attacked by stem borers and caterpillars. The latter were removed by hand, a difficult operation as the creatures concealed themselves during the day. This attack lasted for four weeks. It was estimated that 50 per cent. of the crop was attacked but the sequel proved that the plants received no material injury. The first picking was started on the 15th January; this gave 14 lbs. 7 oz. of seed cotton; the second was on the 25th February and gave 72 lbs. of seed cotton, the third and

the fourth on the 18th March and 1st April respectively and gave 130 lbs. (per acre 216 lbs. 7 oz.). The percentage of lint 1st picking—33·25; 2nd—34·12; and the 3rd—34·37.

The valuations showed that the resulting clean cotton was of very poor quality, the report being that it was no better than Bengals. The first, second and third pickings were valued at Rs. 280, Rs. 275 and Rs. 260 per candy of 784 lbs. Broach cotton in the same day's market being Rs. 330, Surat Rs. 345, and Navasari Rs. 360. Under normal circumstances *Bhuri* in Bengal stands at least as high as Broach. The unfavourable result was, however, instructive in that it suggested experiments with this cotton in various soils to determine the actual influence of soil on the final product.

Kulthi is probably the best rotation for cotton in this soil as it is already the custom to grow it here, and the heavy rainfall forbids the idea of growing *Jowar*. Kumpta was tried on a small plot, but, as was naturally to be expected, it was a failure.

The Cambodia cotton plants suffered so badly from the attacks of caterpillars that only a very few plants survived. They remained stunted in growth and the situation was manifestly unsuitable to them.

These two varieties were also sown on black soil at Aravadgi, about 2 miles distant from Kumbarganvi. The crops on the whole were superior to those at Kumbarganvi, but they suffered from the same insect attacks and in addition became so badly infested with Aphides that they had to be treated with spraying of kerosine oil emulsion.

Cambodia and *Bhuri* produced at Vadgaon from the same seed in 1910 were reported on by Messrs. Tata Brothers as being equal to Superfine Wardha Good at Rs. 340 and Fine Hinganghat Good at Rs. 340 respectively. This further exemplifies the effect of the soil on the quality of cotton, and trials, suggested by these valuations, are being undertaken during the present year at additional centres in order that we may ascertain the precise effects on the cotton

plant and its ultimate product induced by diverse climates and soils.

Another report from Khanapur gives a valuation of *Bhuri* at Rs. 370 and Cambodia at Rs. 340.

The 1910 crop of *Bhuri* at Kumbarganvi was valued at Rs. 380, Fine Surats of the same day being Rs. 380.

In the light of the second year's valuation it is difficult to understand why the first year's crop at Kumbarganvi should have been so inferior.

The Professor of Agriculture, Poona, kindly allowed me the use of a plot of land at Lonavla (where the average rainfall is 186·56 inches) to test the behaviour of *Bhuri*, Cambodia and *Kil* under a very heavy rainfall. The last-named, in its own home in the Garo Hills, luxuriates in almost quite as heavy a rainfall. Seeds of the three varieties were sown on the 19th June, Cambodia germinated well, but *Kil* and *Bhuri* only indifferently. The heavy rains and cold winds prevented further growth in the two latter and they died. Cambodia held out till about the end of July and finally succumbed in the heavy rain of August. It was a foregone conclusion perhaps that no cotton will withstand such heavy and continuous rainfall, but still it is satisfactory to obtain tangible proof of the fact.

Bourbon Cotton Cultivation on the Western Coast.—In former years it was demonstrated to their own satisfaction by a few enthusiasts (who probably owed their success to watchful care), that Bourbon cotton could be profitably grown in the Konkan, and sporadic plants are certainly persistent and quite common in villages. To arouse fresh interest in the subject I persuaded some Mamlatdars to induce land-owning friends to make experiments and I supplied the necessary seed. The final reports, however, proved disappointing as, owing to heavy rains, not one trial resulted in success. Now that a Divisional Inspector has been appointed for the Konkan I hope that, under his supervision, further trials with Comilla cotton, a plant from a heavy rainfall area, may show some measure of success.

Cotton Crop Experiments conducted on the Dry Farm Experimental Station of Ahmednagar.—Here we have adverse conditions under another aspect, namely, of drought and not excessive rainfall. The season on the whole was reported to be good, but the rainfall was above the average and towards the end of the season was also untimely. The germination of the seeds was therefore affected by the packing of the soil which occurs during heavy falls of rain. The subsequent resowing of the numerous gaps and more than usually rapid growth of weeds threw an excessive addition to the normal cost of cultivation. The first picking when approaching maturity was destroyed by the heavy downpour in the *Swati* rains. The plants, however, recovered, but the occurrence of a sudden frost finally destroyed the crop. *Karkeli* on the whole proved most resistant, yielding at the rate of 144 lbs. of seed cotton per acre, while 5 types of Khandesh cotton gave 94, 100, 104, 112, 114 lbs. respectively. Although due attention was paid to all the details of treatment and cultivation, no workable precautions could possibly be employed to insure the crops against the vicissitudes of such an abnormal season.

The following are valuations by Messrs. Tata Sons on samples from Ahmednagar :—

No.	Name of cotton.	Remark.	Valuation.
			Rs.
1	Karkeli . . .	Equal to F. Barsi Gd., which class is very rare or non-existent. Soft in feel and of good staple.	330
2	N. V. M. type . .	Same as above, but slightly better in staple.	335
3	N. V. K. type . .	Same as No. 1, but slightly inferior in staple.	325
4	N. V. type . .	Same as N. V. K.	325
5	N. R. C. type . .	Rather rough and very short in staple ; more like Khandesh.	305
6	Khandesh . . .	This is a superior quality of Khandesh cotton, superfine in colour. The district rarely, if ever, produces such cotton.	315

Basis.—Khandesh Gd. Rs. 310 per candy of 784 lbs.

Cotton Crop Experiments on the Dhulia Experimental Station.—I visited this station on the 29th November.

The first plot of cotton inspected was labelled N. R., a selection of *Neglectum roseum* out of the types ordinarily grown in the fields. The plants were robust, the stand even and the production excellent. The staple is that of *Varhadi*. Last year the produce of this was above 900 lbs. of seed cotton per acre with a percentage of 37·5. The seed cotton is bought by the merchants at the rate of Rs. 21-8-0 per maund (144 lbs.) against the rate of Rs. 20-8-0 per local cotton.

The second plot was of N. R. C. (*Neglectum roseum cutchicum*). This is also a selection from the local cotton. The crop produced last year was 850 lbs., percentage 35. The staple is a little longer and finer than that of N. R. and the cotton was valued at Rs. 10 more per candy (784 lbs.).

The third plot was that of *malvensis*, N. V. M.; differs from *vera* proper or *Jari* in the superiority of its staple. It has been grown on a large scale only this year.

Comilla Cotton.—Fresh seed was imported this year from Hill Tipperah as the acclimatized plant had deteriorated. The lobes of the leaves are broad as well as narrow and the flowers are usually white, but some are yellow. The crop is very poor and very late.

Bhuri.—This plot looks good and productive. One cultivator at Amalner is said to have 20 acres of good *Bhuri* under cultivation. There is a rising demand for its seed and the prospects of success in Khandesh as in Berar are decidedly hopeful at present.

Cambodia looks more sturdy than *Bhuri* but it is a later crop. The prospects of both are of course uncertain until they have been subjected to the experience of a dry season. The cultivator at Amalner, already mentioned, has obtained from the merchants Rs. 10 per maund (144 lbs.) of seed cotton over the price of local cotton.

Of the crosses, that of *Comilla* with *Bani* is most promising as regards both quantity and quality. The selected

plants yield a staple over $\frac{3}{4}$ inch and ginning percentage of about 33.

Karkeli is not very promising, but still it yields a profit quite equal to that of the local crop.

Bani from Akola looks well, but it will never be a favourite crop in a tract where the cultivators prize the qualities of hardiness and high percentage of cotton.

Neglectum var. *kathiawarensis*.—The growth is very vigorous and prolific. Last year it yielded 741 lbs. of seed cotton per acre, with a percentage of 27·10.

The following are some of the results obtained on the station :—

Name	Seed cotton per acre.	Percentage.
Neglectum *var.* malvensis . .	686	26·10
„ „ vera . . .	729	30·00
„ „ cutchica . .	780	35·50
„ „ rosea . . .	870	37·50

Inter se crossing in *Bhuri* and Cambodia has produced enormously strong plants.

As in the Central Provinces and Berar so also in Khandesh the same difficulty in the distribution and maintenance of the pure varieties has to be surmounted. So far there is only one demonstration plot, *viz.*, at Amalner, where the different types are grown. There is also a demonstration held at the Experimental Station every October and this had the desired effect of introducing the improved varieties to the attention of the cultivators who send in orders for seeds. In the local practice, seeds are sown through two tubes placed behind and dragged after the *bhakar*. This requires the attention of three people while the Gujerat drill (which is being introduced) only requires two. The Gujerat bullock hoe is also said to be more effective, as it brings the earth better round the plants.

The Manager of Messrs. Volkart's Spinning and Pressing Factory informed me that he was buying extensively pure supplies of the very coarse *Varadi* (*roseum*) cotton which he considers does really possess a staple. He says that this cotton is mostly used in Germany, Austria and Hungary and that *Bengals* are used in Italy. Fraudulent practices are obviously carried on by cultivators. Wet and damaged cotton is packed into the centre of finer stuff and much leaf and dirt is present. The dry, brown leaf is not so objectionable because it can be blown away, but it is difficult to free the cotton from the black leaf caused by damp.

Khandesh cotton seed bears a good reputation in the European market, its refraction being only 6 per cent. while that from Berar is $6\frac{1}{2}$ to 7.

The cultivators, as a rule, do not take away the seed during the ginning season, but just before sowing time, when they have made up their minds as to what they are to grow, they take whatever they can get in the shape of seed from the mounds in the compounds of the ginning factories. A few of the more careful cultivators, however, especially those who farm on a large scale, bring their seed cotton to the ginning factory, see it ginned in their presence, and often sell it during the process to the highest bidder. They take away there and then what they require for the next season's sowing.

Cotton Experiments at Sholapur.—I visited these in January in company with Mr. Patil, the Divisional Inspector of Agriculture. The first plots seen were at Mohanmala on land owned by the late Rao Bahadur Warad. These experiments were started last year with the object of ascertaining the mixture existing in the cotton fields of the Sholapur District and also the value of the component parts of such mixtures.

The seeds were collected from all the talukas of the district. Mr. Patil has separated out these types and furnished the following analysis :—

A statement showing the Analysis of Cottons in the Sholapur District, 1910-11.

				NEGLECTUMS.						
Plot No.	Name of village from which the seed was obtained.	Name of Taluka.	Total No. of plants in each plot.	White flowered broad lobed.	Yellow flowered broad lobed.	White flowered narrow lobed.	Yellow flowered narrow lobed.	Broach.	Upland Georgian.	REMARKS.
1	Peha	Pandharpur	166	·6	63·25	1·8	17·46	·6	16·26	
2	Jeur	Karmala	123	0	23·57	·81	10·56	63·4	4·06	
3	Tadola	Barsi	93	0	69·9	6·45	13·9	4·36	5·37	
4	Pomalwadi	Karmala	74	0	40·5	1·3	10·8	40·5	6·7	
5	Tembhurni	Ditto	49	0	59·18	2·03	14·3	18·3	6·1	
6	Malshiras	Malshiras	75	0	76·0	4·0	14·6	4·0	1·3	
7	Akluj	Ditto	88	0	58·0	3·4	6·8	25·0	6·8	
8	Vairag	Barsi	51	0	80·4	0	9·8	5·88	3·92	
9	Sangola	Sangola	36	0	55·5	0	19·44	2·8	22·2	
10	Bhalani	Pandharpur	83	1·2	56·6	0	20·4	14·4	7·2	

I understand from Mr. Patil that the experiments are to be transferred to Karmala, about 12 miles from Jeur Station. The villagers there have lost their crops through the use of unsuitable seed obtained locally from ginning mills. The cotton usually grown by them is a mixture of neglectum with a little Jowari Hatti and Upland. The people prefer the narrow-lobed neglectum and say that they are willing to buy up any quantity of seed. The rainfall is said to be precarious and the methods of cultivation poor so that the locality seems altogether unsuitable for high class cottons. I have recommended that pure varieties of neglectum be obtained either from Dhulia or from Akola. We have since sent 1,300 lbs. of Varhadi seed to Mr. Patil, also 150 lbs. of Saugor-Jari seed, an early ripening dwarf, prolific variety, which ripens its crop at least three weeks in advance of Jari and Varhadi: I also visited Pasare's Estate on which the Department is working with manurial experiments.

The following are valuations by Messrs. Tata Sons on samples sent from each of the treated plots :—

No.	Description of sample.	Report.	Price per candy.	Remarks.
			Rs.	
1	Plot manured with F. Y. manure.	Strong in fibre and of good staple and has the appearance of the usual cotton of the Sholapur District.	335	Western style.
2	Plot manured with pot-sulphate and superphosphate.	Weaker in staple than No. 1 .	325	Ditto.
3	Plot manured with ammonia sulphate and superphosphate.	Staple and strength of fibres between Nos. 1 and 2.	330	Ditto.
4	Manured with superphosphate.	Equal to No. 1 . . .	335	Ditto.
5	Manured with ammonia sulphate only.	Equal to No. 3 . . .	330	Ditto.
6	Check plot; no manure .	Equal to No. 1 . .	335	Ditto.
7	Manured with pot-sulphate only.	This is the best of the whole group in colour, length of staple and strength of fibre.	340	Ditto.
8	No manure; check plot .	Equal to No. 1 . . .	335	Ditto.
9	Manured with ammonia sulphate, superphosphate and pot-sulphate.	Equal to No. 2 . .	325	Ditto.
10	No label . . .	Equal to No. 1 . . .	335	Ditto.

Basis.—Good Western Gd., Rs. 335.
Fine Broach Gd., Rs. 360.

Again, in company with Mr. Patil, I visited the experiments with Broach cotton (seeds imported from Navasari last year) near Islampur in the Krishna Valley. This is a highly cultivated and fertile tract and agricultural operations have been very carefully attended to.

In the first field local Jowari Hatti and the imported Broach are growing side by side. The former was ripening, while the latter bore only flowers and unripe bolls.

In another field of imported Broach, sown in June, the bolls were ripening. From the conditions of these two trials one sown in the end of July and the other in June, it is plainly obvious that no delay should occur in the sowing of Broach cotton in this district. I also suggested the trial of *Bhuri* and Cambodia in this tract.

The following are valuations of local Jowari Hatti and Broach cotton grown in adjacent plots on these trials :—

No.	Report.	Price per candy.	Remarks.
		Rs.	
1	If the seed is Bengal, it has certainly improved in Islampur soil and looks more like Miraj cotton.	335	Western style.
2	Same remark as above ; it is better in colour than No. 1 .	340	Ditto.
3	Shows deterioration in colour only	390	Surat style.
4	Better than No. 3 in colour, but slightly shorter in staple .	385	Ditto.

N.B.—Nos. 1 and 2 are Jowari Hatti; Nos. 3 and 4 are from seed imported from Navasari.

Basis of valuation per candy :—
Fine Surat Gd., Rs. 380.
„ Broach Gd., Rs. 360.
Good Western Gd., Rs. 335.
(Candy of 784 lbs.)

Some experiments are being conducted at Nadiad in the Kaira District to solve the very difficult problem of finding a better cotton than the local Rosi.

Three varieties are at present under trial; Bourbon, *Bhuri* and Cambodia :—

Bourbon.—This was the second year of its growth. During the first year it yielded 400 lbs. of seed cotton per acre, second year, 1,000 lbs. of seed

cotton per acre. The second year's growth was extremely satisfactory, so much so that the branches had intermixed and it was impossible to go into the field. It remained to be seen whether after pruning (third year) the outturn is maintained.

Bhuri.—This was sown in May under irrigation only until the rains broke; outturn 1,100 lbs. of seed cotton per acre.

Cambodia.—Sown in May under irrigation like Bhuri; outturn 800 lbs. of seed cotton per acre.

It seems that both *Bhuri* and Cambodia should be established before the rains to reap a good harvest. It was gathered that cultivators from the neighbourhood occasionally visited the farm and were satisfied with the growth, outturn, etc., and as a consequence of this the Superintendent has received many requisitions for the supply of seed of all the three varieties mentioned above.

Samples were valued by Messrs. Tata, Sons & Co. as follows:—

	Rs.	
Fine Surat	380	per candy of 784 lbs.
Navasari	400	
Fine Broach	360	

Valuation of Nadiad Samples—

Bourbon—Equal to F. Navasari Gd., good in colour and staple, Rs. 400.

Cambodia—Equal to F. Broach Gd., but better in staple, Rs. 365.

Bhuri.—Equal to F. Broach Gd., Rs. 360.

From these valuations it will be seen that there is a strong possibility of at least three high class cottons being introduced profitably into Northern Gujerat.

Full reports of the cotton operations on the Bombay Experimental Stations will be found in the Progress Reports. Mr. Keatinge, the Director of Agriculture, in a recent note has clearly shown the present condition and prospects of cotton cultivation in the Bombay Presidency. This is entitled "Note on Improved and Exotic Cottons in the Bombay Presidency." It should be carefully studied by all who are interested in the improvement of Indian cottons.

Madras Cottons.

Good work is being done in the Southern Districts of the Presidency judging from the samples of selected cottons which were sent to me for valuation.

These were adjudged by the Directors of the Bombay Cotton Association, Limited, who remarked that all the samples showed nice clean cotton and the differences in price is all practically due to staple. That the Karunganni samples are *more* suitable for weaving mills than the Uppam samples, but both styles should suit buyers for export and local consumption.

The following is their detailed report :—

Samples of cotton from Madras submitted by the Imperial Cotton Specialist :—

	Rs.
Basis—Fine M. G. Broach	350
,, Fine M. G. Navasari	375
,, Fine G. F. Tinnevelly	345

Serial No.	Description.	Approximate market value in Rs. per candy of 784 lbs. less 5½ per cent. discount.	Remarks.
	Uppam Variety.		
1 U	Ordinary field crop . .	335	Rather harsh in staple ; very clean.
2 U	Pedigree Uppam	340	Staple rather better than No. 1.
3 U	Ditto	340	Ditto.
4 U	Ditto	335	Ditto.
5 U	Ditto	335	Ditto.
6 U	Ditto	345	Ditto.
7 U	Ditto	340	Ditto.

Serial No.	Description.	Approximate market value in Rs. per candy of 784 lbs. less 5½ per cent. discount.	REMARKS.
	Karunganni Variety.		
1 K	Karunganni ordinary field crop .	345	Silky staple.
2 K	Pedigree Karunganni . . .	345	Ditto.
3 K	Ditto	345	Ditto.
4 K	Selected Karunganni . . .	345	Ditto.
5 K	Ditto	343	Ditto.
6 K	Pedigree Karunganni . . .	350	Ditto.
7 K	Ditto	345	Irregular in staple.
8 K	Ditto	345	Staple rather irregular.
9 K	Ditto	350	Staple good and silky.
10 K	Ditto	340	Ditto.
11 K	Ditto . . .	345	Ditto.
12 K	Ditto	370	Long silky staple, excellent, spinning cotton.
13 K	Ditto	370	Ditto.
14 K	Ditto	375	Ditto.
15 K	Ditto	380	Ditto.

It will be seen from the above that the selections have been valued almost in their correct order by Mr. Sampson.

Bengal Cottons.

I visited the Experimental Station at Chinsurah and furnished the following report, which was based on an inspection and discussion with Mr. Smith, Deputy Director of Agriculture.

The first plots seen were of Cambodia and Bhuri cottons, one-fifth of an acre each. These were on well-drained raised land and their condition was very satisfactory indeed. As explained to me, I gathered that this class of land is very rare in the province, its height above the general level being due to an accumulation of silt and weeds thrown up while excavating tanks. It is the most suitable of soils for plantains, etc., and we can scarcely expect a cotton crop to compete with these in value. The second series of plots visited were of the same cottons on paddy land, lying at the general level. The plants were unthrifty and showed distinct signs of damage by water-logging earlier in the sea-

son. Practically no crop had been produced and the immature bolls were shrivelling. The plots of indigenous varieties were only just coming into flower. This means that bolls could only be ripened during the hot weather, and as their produce at the best would only be equal to the most inferior Berar or Khandesh cotton, they are scarcely worth troubling with in a tract which grows more highly remunerative crops, such as rice and jute. *Deshila* and *Bhogila* are still later and the length of time they occupy the ground is a serious objection to their cultivation. It is to be regretted that the primitive people of Chutia Nagpur cannot be induced to extend the cultivation of Bhuri cotton in their country, but, so far as they are concerned, there is probably no material incentive for them to so exert themselves.

All the Indian varieties of cotton have now been tried in the deltaic area of Bengal, and the inevitable conclusion to be drawn from the experience thus earned is that the conditions of soil and climate are not in any way suitable for cotton cultivation, and I cannot recommend that experiments with a view to introduce their culture should be persevered with.

The following samples from Chinsurah, Bengal, were kindly reported on for me by Messrs. Tata, Sons & Co. of Bombay :—

No.	Name.	Report.	Price per candy.	Remarks.
			Rs.	
1	Cambodia . . .	The cotton has preserved its silkiness and staple, but has deteriorated in class. It is F. G. in class.	300	Bengal style.
2	Bhuri	Better than No. 1 . .	310	Ditto.
3	Deshila	Very much deteriorated, and is like G. Bengal.	275	Ditto.
4	Bhogila	Deteriorated and can be likened to F. G. Bengal.	285	Ditto.

Basis per candy of 784 lbs.—
F. Bengal, Rs. 315.

It will thus be seen that no very remunerative cotton has as yet been established in Bengal.

Punjab Cottons.

Excellent results are being attained by Mr. Milne, the Economic Botanist, as will be seen from the account published in his progress report and by the British Cotton Growing Association, Manchester. It was considered that 161 A. F. was the best, while Pride of Georgia coming second is nearly equal by 199 F., 220 F., and King's Cotton is slightly lower than the last three. The reports on the indigenous cottons are not so favourable. It is to be hoped that the extension in the cultivation of the higher class cottons in the Punjab will be persevered with.

Valuations.—All samples received were submitted to Messrs. Tata, Sons & Co., Bombay, for valuation. Cordial acknowledgment is due to these gentlemen for their kindness and promptitude in giving opinions on cottons whenever submitted to them.

Some samples were also submitted to the Bombay Chamber of Commerce, to whom thanks are also due.

Programme of work for 1911-12.—1. To visit and advise on points regarding cotton and its cultivation whenever requested to do so by Provincial Departments of Agriculture.

2. By special invitation of the Department of Agriculture, Punjab, to report on the work done in the way of cotton improvement in that province. The question of the distribution of seeds of improved varieties will be further discussed with the proper authorities in the Central Provinces and Bombay Presidency.

3. The study of the behaviour of Bourbon, *Bhuri*, and such other cottons in non-cotton producing tracts as detailed in my last year's programme will be continued.

4. The conditions of cotton cultivation in Kathiawar and adjacent parts would be investigated.

5. An enquiry will be commenced on the manurial requirements of cotton.

PUBLICATIONS.

Article on Caravonica Cotton. Agricultural Journal of India, Vol. V, Part III.

The present position and prospects of Cotton Cultivation in India. For the International Congress of Tropical Agriculture, Brussels, May, 1910.

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REPORT

OF THE

Agricultural Research Institute and College, Pusa

(Including the Report of the Imperial Cotton Specialist)

1911-12

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Report of the Agricultural Research Institute and College, Pusa,

(*Including the Report of the Imperial Cotton Specialist*)

1911-12.

REPORT OF THE DIRECTOR.

(B. COVENTRY, C.I.E.)

1. *Charge.*—Dr. E. J. Butler held charge of the office of Director, Agricultural Research Institute, and Principal of the Agricultural College, Pusa, in addition to his own duties of Imperial Mycologist till the end of March 1912. At the end of the financial year 1911-12, the two posts of Inspector General of Agriculture in India and of Director, Agricultural Research Institute, Pusa, were amalgamated into one of Agricultural Adviser to the Government of India and Director of the Agricultural Research Institute, Pusa. Since that date, I have held charge of the combined offices. Mr. A. C. Dobbs, who was formerly Assistant Inspector General of Agriculture in India, held the post of Assistant to the Agricultural Adviser to the Government of India till 28th April 1912, when he proceeded on six months' combined leave.

2. *Staff and work of the Institute.*—The work of the Institute as carried on in the seven scientific sections into

which it has been organised has been detailed in the reports of the several sections which are embodied in this report.

The Chemical Section was in the charge of Dr. J. Walter Leather. Mr. H. E. Annett, the Supernumerary Agricultural Chemist, was, till November 6th, 1911, on deputation to the United Provinces Department of Agriculture, to act as Principal of the Cawnpore Agricultural College. He left Pusa again on 9th May 1912 to act as Agricultural Chemist to the Government of the Punjab.

Mr. A. Howard was in charge of the Botanical Section. From July to September 1911 and during May and June 1912, he was at Quetta in connection with the development of the Fruit Industry in Baluchistan. The services of Mr. E. Holmes-Smith, the Supernumerary Botanist, were terminated on 7th October 1911.

The Mycological Section was in charge of Dr. E. J. Butler, throughout the year except from 17th June to 6th July 1912, when he was on privilege leave: during this period Mr. F. J. F. Shaw, the Supernumerary Mycologist, officiated for him.

Mr. H. Maxwell-Lefroy, the Imperial Entomologist, was on long leave throughout the year. Mr. T. Bainbrigge Fletcher, Supernumerary Entomologist, held charge of the section until April 19th, 1912, when he proceeded to Coimbatore to take up the new appointment as Entomologist to the Government of Madras. Mr. A. J. Grove joined his appointment as Supernumerary Entomologist on October 27th, 1911, and since Mr. Fletcher's transfer to Madras, has carried on the work of the Entomological Section.

The designation of the Second Imperial Entomologist has been altered to that of Imperial Pathological Entomologist, and Mr. Howlett held charge of the section throughout the year.

The Bacteriological Section was in charge of Mr. C. M. Hutchinson.

The Agricultural Section continued under the charge of Mr. A. C. Dobbs, until April 27th, 1912, when he proceeded on leave. Mr. S. Milligan, Deputy Director of

Agriculture, Punjab, has been transferred to this Institute to take up the post of the Imperial Agriculturist. He joined the appointment on May 8th, 1912. Mr. H. Southern, Supernumerary Agriculturist, who had been officiating Deputy Director of Agriculture, Madras, was transferred to the Punjab in April last to take up the appointment vacated by Mr. Milligan. Mr. G. D. Mehta was appointed Supernumerary Agriculturist on 4th June 1911. Until 30th May 1912 he was working at Poona under the Government of Bombay and from that date he has been posted to the Central Provinces for training. Messrs. W. S. McGowan and Thomas Gilbert were appointed Supernumerary Agriculturists on 23rd February 1912. The former is posted to Bihar and Orissa to act as Professor of Agriculture at the Agricultural College, Sabour, and the latter is working under the Government of Bombay.

3. *Agriculture.*—The rainfall during the year amounted to 56·30 inches. The monsoon arrived early and gave a plentiful rainfall. Floods, however, damaged the *kharif* crops, while late rain retarded the sowing of the *rabi* crop. The permanent manurial and rotation experiments started in 1908 with the object of studying the maintenance of the fertility of the soil have been continued. It is too soon yet to expect definite results from these experiments. The improvement of the sugar-cane crop on the ridge and furrow system combined with intertillage has been taken up and promises to be an important advance upon the methods in vogue in North India. It is proposed to apply the same system in a modified form to some of the *kharif* crops such as maize, which have already shown great improvement from liberal spacing and intertillage as well as from the free drainage induced by ridging. Among the use of chemical manures the application of crude sulphate of soda to paddy gave an increase of 17 maunds of grain per acre. This is a preliminary result requiring confirmation. The application of green manuring with *san* hemp combined with the moderate application of superphosphate at the time of sowing the *san* continues to give good results and is

the chief means by which the fertility on the farm is maintained against heavy and continuous cropping.

A new and important feature in the experimental work on the farm is a series of plots in which the biological factor connected with the use of green manuring as well as other bacteriological problems will be studied by the Imperial Agricultural Bacteriologist in conjunction with the Imperial Agriculturist. Too much stress cannot be laid on this work, which is now generally recognised as affording a most promising field for research into the principles underlying the fertility of soils.

4. *Chemistry.*—The work on the availability of plant food in soils and that of the moisture requirements of crops to which reference has been made in previous reports is being continued. The examination of water after passing through certain depths of soil continues to be carried out. It has been observed that not only is there less nitrate in the drainage water from the cropped soil than from fallow land, but the deficiency could not be accounted for merely by assimilation by the crop. Dr. Leather, therefore, deduces that either less nitrate was formed in the presence of the crop or some other agent than the crop was assimilating the nitrate. The investigations in *Usar* soil which have been going on for some years have so far not led to any very useful or definite results.

In the last Annual Report mention was made of the investigation into the date-palm sugar-industry which was carried on by Mr. Annett, the Supernumerary Agricultural Chemist. This has been continued during the past year and has led to an accumulation of very valuable information on the subject, which is now in the press and will soon appear as one of the Memoirs of this Department. Besides recording the history of this industry Mr. Annett gives a good description of the cultivation and tapping of the palm and the manufacture of the raw and refined sugar. He found that the juice contains 8 to 10 per cent. of sucrose, associated with practically no glucose. This fact indicates that it is an exceedingly good materials for the production

of white sugar direct from the juice. Owing, however, to imperfect methods of collection, 1 to 2 per cent. glucose is formed during the night and this amount is again greatly increased by the subsequent primitive treatment, thereby occasioning very great loss in white sugar. In an account of this work Mr. Annett draws attention to the great improvements which have been introduced into the corresponding American Industry of Maple Sugar, though in this case the juice which forms the raw material contains only 3 per cent. of sucrose. If improved methods could be applied to the Indian Palm Sugar Industry, there is no doubt not only that it would add to the profits of the sugar maker, but that the white sugar produced would assist to some extent in checking the encroachment of foreign white sugar into this country. The importance of this problem can be gauged by the fact that the production of sugar from the palm tree in India amounts to some 480,000 tons.

Some important work has been carried on in the Chemical Section during the year in the endeavour to establish a reliable method of milk tests for Indian cattle. When testing cows' milk in India two sources of error have to be guarded against; (1) if the periods between milking are not equal, the composition of the milk will be influenced, and (2) the calf will take an indefinite amount of milk if this is not controlled. In order to eliminate these sources of error the cows are milked exactly at intervals of 12 hours, and the calf is allowed to take the whole of the milk from only two teats on one side of the udder, the other side being milked by hand and the calf being made to change the side every 24 hours. In this way the difficulties described were overcome. While great regularity was as a rule obtained in the composition of the milk, yet it was possible to observe characteristic differences. The chief of these was that the percentage of butter fat in the morning was greater than that in the evening milk by ·5 to 1·5 per cent. and there was no exception to this rule. No systematic difference was found, in the composition of the milk, between the different sides of the udder.

5. *Botany.*—The wheat work continues to absorb a very large portion of the time of this section. The extended trials of the past year go to confirm previous results, and give prominence to the important fact that high yielding power and good grain qualities can be combined in the same plant. Stress is again laid upon the need of good cultivation and the repeated favourable results obtained therefrom entirely warrant this. As so much of the wheat exported from India is grown under irrigation it was important to ascertain by experiment whether wheats of good quality and high yielding power could be obtained in the canal districts. This has been done. Extended trials of the Pusa wheats have been made at Cawnpore and yields of over 2,200 lbs. per acre and in one case of 2,500 lbs. were obtained with a single watering. That is to say it was obtained with one-third of the water usually used by the cultivators in the neighbourhood. As regards quality they were found to possess baking qualities equal, if not superior, to the wheats grown at Pusa without irrigation. Mr. Howard, in this year's report, gives detailed accounts of the results of the extensive trials which were made of his wheats, in the wheat tracts of India, to which reference is invited. Owing to the success of these experiments, a great demand has arisen in various parts of India for the new wheats. Arrangements have, therefore, been made, to grow during the coming season, a large stock of seed, which it is expected will meet all demands.

Experiments on the influence of the environment on the quality are being continued and extended, with the object of finding out how far high quality in grain is possible in different wheat tracts. If wheat of good quality such as has been grown at Pusa and Cawnpore could be grown in any of the wheat tracts of India, the fact would be of very great importance, as the Indian wheats of commerce are mostly of poor quality. So far wheats grown on such varied soils as the alluvium and the black cotton soil did not lose their milling and baking qualities. Mr. Howard likewise maintains that in any particular wheat the condi-

tions which produce the highest yield are those which produce the best quality.

Not by any means the least important aspect of the work on wheat is that of breeding. Rust resistance, high yield, and strong straw in order to carry a heavy weight of grain are points to which attention is being particularly devoted.

Amongst other important investigations are those connected with the tobacco plant. The object of these experiments is to endeavour to establish a suitable plant for the manufacture of cigarettes, which are fast supplanting the *hooka*. Three types Nos. 28, 29 and 32 were grown and were cured by a slight modification of the country method. The whole of the crop was sent to the Peninsular Tobacco Company at Monghyr and made into cigarettes. Type 28 was very well reported on and was valued at from Rs. 12 to Rs. 14 per maund which is a considerable advance on local prices. Arrangements are now being made to repeat these results if possible amongst the cultivators.

Gram is another important crop to which Mr. Howard has been giving his attention, and he has shown by preliminary trials that there exists a very large margin on which to work out improvements both in yield and quality. Thus as the result of samples sent to Messrs. Ralli Brothers one variety was valued at Rs. 4-8-0 per cwt. and another at Rs. 5-8-0 per cwt. as compared with the price of Rs. 4-2-0 of the ordinary export varieties. The yields too were extraordinarily high being over 30 maunds per acre.

The work on the botanical characteristics of fibre plants and the study of the methods of pollination in the various Indian crops are being continued.

The development of the Fruit Industry of Baluchistan is a piece of work which is now assuming important proportions, and a fruit experiment station has been established about two miles from Quetta. It will take some little time before the model fruit garden comes into bearing, but in the mean time an old fruit garden has been taken over and improvements are being applied to it. The questions of packing and transport are being thoroughly gone into and

the results of the past season's experiments give promise that the cheap, quick and safe transit of first quality fruit to any part of India will soon be an accomplished fact.

6. *Mycology.*—An investigation is in progress into the disease of paddy known as *ufra* which is causing great damage in the Noakhali and other districts of Eastern Bengal. At first it was not known whether it was caused by a fungus, an insect, or some other cause. A conjoint entomological and mycological investigation resulted in the exclusion of insects as the direct cause and suspicions have been thrown upon an eel-worm so small that it is barely visible by the naked eye. It is estimated that in the Begumganj Thana alone, in the Noakhali district, some 200,000 maunds of grain was destroyed in 1910, and last year about half the crop was destroyed. The disease also occurs in Comilla, Chandpur, and the neighbourhood of Dacca. Dr. Butler, the Imperial Mycologist, is devoting special attention to this disease.

Mr. F. J. F. Shaw, the Supernumerary Mycologist, has devoted a great deal of attention to the rot induced by the soil-dwelling parasite known as *Rhizoctonia*. Its existence is very widespread, and it attacks crops such as potatoes, jute, groundnut, cow-pea and cotton, though so far cereal crops fortunately appear to be immune to this disease. Good tillage and a suitable rotation of crops are thought to be the best ways of preventing its ravages.

Further work has been done on wheat rust, which is a serious disease in this country in certain years. Thus there was last year a severe attack in the Central Provinces, the first for a number of years. The damage was caused by the variety known as " Orange " rust (*Puccinia triticina*) and much of the loss in 1912 must be attributed to it. In breeding rust resistant wheats therefore, for the Central Provinces, Dr. Butler is of opinion that this variety of rust should be taken into account, as well as the " black " rust (*Puccinia graminis*) which does much damage in normal years. The variety known as " yellow " rust (*Puccinia glumarum*), does not appear to be of importance. Diseases due to *Phytophthora*, Sugarcane diseases, among others one

resembling *Sereh* and occurring on the Jorhat Farm in Assam, the Betelnut Palm disease, the Indigo disease and other diseases, connected with tea, cotton and coffee, as well as diseases of forest trees, have engaged the attention of this section during the year.

A very large amount of systematic work has also been done, and some hundreds of specimens, of plant parasites for the most part, have been added to the named herbarium collection. Two parts of the list of Indian fungi were prepared in collaboration with Messrs. H. and P. Sydow of Berlin, and published—containing some 300 species of Indian fungi, of which more than a hundred were new to science.

7. *Entomology.*—In Madras a campaign has been carried out against the Deccan Grass-hopper. The method known as "bagging" was adopted, more or less successfully, and the ploughing of infested lands was carried out. Besides this a leaflet was issued in English, and in the vernacular, giving a description of the methods to be adopted against this pest. Experiments against White Ants were continued in the Central Provinces. The application of kerosene oil was found most effective in dealing with the mound-building variety of termites. The collection and despatch to the Punjab of parasites of the cotton boll-worm formed an important aspect of the work of the section, as dependence is placed upon this parasite in order to keep in check the ravages of the insect. This method of controlling this pest is being adopted in Egypt, and parasites have recently been sent to that country for this purpose. A leaflet has been issued in the vernacular explaining how this remedy should be used. In the United Provinces measures have been adopted against the Rice Grass-hopper which has become a serious pest of sugar-cane in that province. The method of storing seed potatoes in sand as a protection against the Potato moth was successfully demonstrated to cultivators in Bengal. At Mokameh a campaign was organised against *Agrotis ypsilon*, a caterpillar which has been destroying the crops in that region. The picking off

of the first brood of caterpillars and the setting up of the Andres-Maître traps reduced the damage to such an extent that, out of a total area of 20,000, only 2,000 bighas were affected.

Sericulture has continued to claim a large amount of the attention of the section. Experiments are in hand for crossing the Indian multivoltine variety of mulberry silk-worm with the univoltine races from Europe, with the object of producing a superior silk-producing multivoltine hybrid. If this work is successful it will go a very long way towards placing the Indian silk industry, now in a precarious position, on a more stable footing. Eri-silk culture, Lac-culture and Api-culture continue to occupy the attention of the section.

8. *Pathological Entomology.*—This section, which was formerly styled the Second Entomological Section, now confines its attention to entomological work connected with the diseases of men and animals, and its name has in consequence been changed. Its relation with medical work has now become much closer, and, through the good services of the Medical Research Fund, the addition of three posts has been made to the subordinate staff. These extra men will be occupied exclusively with Medical Entomology, while there will be two men available for Veterinary and general work.

Special attention has been paid to the genus *Stegomyia* and allied forms of the mosquito owing to the possibility of importation of Yellow Fever into India from the Panama Canal, and a course of instruction has been given to medical officers belonging to the "Stegomyia Survey." Investigations are in progress on the influence of temperature, range of flight, food, breeding places, etc., and on the natural enemies of mosquito-larvæ.

The other subjects that are receiving attention are the breeding places and habits of *Phlebotomus*, the life history of the Crab-louse, the parasites of *Tabanus albimedius*, *Monophlebus stebbingi*, and the life history of *Celyphidæ*. The East Indian Railway school at Jharipani was success-

fully rid of a plague of bugs by the application of hydrocyanic acid.

9. *Bacteriology.*—The principal work of this section during the past year has been the study of the factors which determine the biological activity of Indian soils, and the devising of methods by which this activity may be ascertained and measured. The usual plan of estimating bacteria by " plating " has been abandoned in favour of the measurement of their resulting physiological activities. Thus, for example, it has been ascertained that the biological activity of a soil is in direct proportion to the rate of formation of carbon dioxide, and that conditions unfavourable to the former will also adversely influence the latter. It is possible in this way to determine the optimum conditions of moisture content, the effect of the addition of various manures, organic and mineral, and the influence which tillage will have upon any particular soil. The biolysis of green manures, root residues, and organic manures, in so far as they form the supply of available nitrogen, has been undertaken.

It has been found that important differences exist in the biological changes that take place in Indian and European soils. These differences appear to be due mainly to the relatively higher temperatures and consequent greater bacterial activity of Indian soils. At temperatures between 15° C. and 18° C. the formation of ammonia is in proportion to the nitrification which follows it, but when temperatures rise from 25° C. to 30° C. ammonification may proceed with such rapidity that nitrification is interfered with, and even inhibited altogether, by an excess of ammonia. If, therefore, large quantities of organic matter are applied to a soil, much nitrogen may be lost in the form of ammonia—which shows the necessity that exists for selecting the most suitable time of year for applying organic manures. It has also been ascertained that where intense bacterial action is taking place in a soil, nitrates present will be reduced, without the occurrence of anærobic conditions, lending support to the belief that the nitrate is

utilised as a source of nitrogen by the bacteria themselves. These considerations tend to show what great care should be exercised in a tropical country like India in the treatment of the soil, if its supplies of plant food are not to be dissipated or wasted, and it also confirms the opinion which is now ripening into positive fact, that the study of the biologic factor in soils is of supreme importance, and that very important results are to be expected from it.

A special enquiry, also, is proceeding into the conditions determining the formation of bacterio-toxins in soils, and into their effect on crops.

10. *Training.*—The training of students on the lines laid down in the Prospectus was continued, and short courses were also given in Cattle and Poultry management, Sericulture and Lac cultivation. Of the two post-graduate students in Agricultural Chemistry, admitted in the previous year, one continued his course, but the training of the second was terminated, as he was considered not likely to prove himself an efficient assistant. The two students in Entomology, mentioned in the previous year's report, left during the year; one after completing his course, and the other before its completion, as he was recalled to his province. The Assistant Director of Agriculture, Punjab, who was deputed to this Institute for a two years' course in general agriculture, completed his training on 21st August 1911, and returned to his province.

During the year under report four new students were admitted for training in Agricultural Chemistry. Of these, two are Government stipendiaries (one from Bengal and one from the Travancore State) and two are private students. A private student deputed by the Department of Agriculture, Travancore, was admitted, for training in general entomology. The Agricultural Department of Bihar and Orissa have deputed an Entomological and Mycological Collector for training in Mycology and Entomology. One advanced student from the Agricultural Department of the Central Provinces was given training,

in the Botanical Section, from October 1st, 1911, to the end of April 1912.

During the year under report, 33 students attended the short courses—two in 'Cattle management,' one in 'Poultry management,' seventeen in 'Sericulture' and thirteen in 'Lac cultivation.'

11. *Buildings and Works.*—During the year under report two small supplementary Laboratories were constructed, departmentally, for the use of the Imperial Agricultural Bacteriologist and the Imperial Pathological Entomologist, respectively. Residential quarters were also constructed for the use of the Superintendent of the Office of the Agricultural Adviser.

12. *Library.*—The Library is rapidly becoming overcrowded. Proposals for its extension have been submitted. During the year under report about 1,400 volumes have been added.

13. *Publications.*—The issue of the Journal, Memoirs and Bulletins was continued. The Department published during the year 14 Memoirs and 4 Bulletins, against 7 Memoirs and an equal number of Bulletins in the previous year. As noted in the last year's report, the Provincial Departments are supplying an increasing volume of contributions for these publications.

In consequence of the abolition of the Journal of Tropical Veterinary Science from 1st April 1912, it has been decided that articles of a popular character on veterinary subjects should be inserted in the Agricultural Journal of India. Contributions unsuited for the Journal, by reason of their being too technical, will be published in the form of Veterinary Memoirs which are now among the Scientific Memoirs issued by the Agricultural Department. They will be issued from time to time as matter becomes available. The editing committee has been strengthened by the appointment of the Imperial Bacteriologist, Muktesar, as a co-editor. The grant for the agricultural periodicals and Journal, which was curtailed

during the previous year to Rs. 23,000 remained unaltered during the year under report, but the Government of India have added Rs. 2,000 for Veterinary Memoirs, so that the total grant for publications now amounts to Rs. 25,000. As the work of the Department expands the matter for publication likewise increases, and the present grant will not be sufficient. It will be necessary to increase the funds for this work.

14. *General Health of the Station.*—The general health of the station during the year under report was good. Relief was afforded to 9,081 new cases, of which 8,913 were treated in the out-patients department, and 168 admitted as indoor patients, an increase of 1,424 cases over last year's total. The increase in attendance was due to the great prevalence of malarial fevers and cholera in the surrounding villages.

Two hundred and ninety-nine cases amongst European officers and families were attended to, an increase of a hundred and fifty-three over last year's total.

The daily average number of patients treated was 7·59 indoor and 53·6 outdoor against 7·87 and 49·05 respectively during the previous twelve months.

Five deaths occurred in hospital—

Two from cholera.
One from malarial cachexia.
One from dysentery.
One from phthisis and pneumonia.

Nine cases of cholera occurred among the families of the Indian staff during the months of May and June 1912 with two deaths. Immediate and successful measures were taken to prevent the disease spreading in Pusa, including the thorough cleansing and disinfection of all the wells in the Estate.

One hundred and twenty-one surgical operations were performed, of which twenty-five were major and ninety-six minor operations.

Quinine was issued prophylactically on the Estate, towards the close of the monsoon.

Twenty-four primary vaccinations and eight revaccinations were performed in the early part of the year.

15. *Accounts.*—The total expenditure during the financial year 1911-12 was Rs. 3,04,045, as under :—

	Rs.
Agricultural Research Institute, Pusa—	
Office of the Director	69,015
Chemical Section	41,012
Mycological Section	19,622
Entomological Section	37,345
Pathological Entomological Section .	24,188
Botanical Section	41,542
Bacteriological Section	22,108
Agricultural Section	49,213
TOTAL .	3,04,045

16. *Visitors.*—Visitors to Pusa between 1st July 1911 to 30th June 1912, numbered among others :—

The Hon'ble Mr. Syed Ali Imam, C.S.I., Bar.-at-Law, Member in charge of the Legislative Department, Government of India.

Mr. Abdul Aziz, Bar.-at-Law, Peshawar.

Mr. C. V. Piper of the United States Department of Agriculture, America.

The Hon'ble Sir R. W. Carlyle, K.C.S.I., C.I.E., I.C.S., Member in charge of the Department of Revenue and Agriculture, Government of India.

The Hon'ble Mr. W. H. Clark, C.S.I., C.M.G., Member in charge of the Department of Commerce and Industry, Government of India.

Mr. R. Nagamine, Director of the Government Stock Farm in Formosa.

Mr. T. Kawakami, Director of the Government Museum, Formosa.

Lieutenant-Colonel C. Norie, Dehra Dun.

Mr. D. Quinlan, M.R.C.V.S., Superintendent, Civil Veterinary Department, Bengal.

The Hon'ble Surgeon-General Sir C. P. Lukis, M.D., F.R.C.S., K.C.S.I., Director General, Indian Medical Service.

The Hon'ble Mr. R. C. C. Carr, I.C.S., Officer on Special Duty in the Board of Revenue, Madras.

Mr. A. E. Andrews, Entomologist to the Indian Tea Association.

Dr. A. D. Imms, Forest Zoologist.

Dr. H. Morstatt, Entomologist at Amani, German East Africa.

Munshi Akhtar Mohammad Khan, Deputy Collector in the United Provinces.

REPORT OF THE IMPERIAL AGRICULTURIST.

(S. MILLIGAN, M.A., B.Sc.)

1. *Charge and Establishment.*—The Pusa Farm and Experimental Station continued under the charge of Mr. Dobbs, Assistant Inspector General of Agriculture in India, till April 28th, 1912, when he proceeded on leave. I joined my appointment as Imperial Agriculturist on May 8th.

Mr. H. Southern, B.A., Supernumerary Agriculturist, who had been officiating Deputy Director of Agriculture, Madras, was transferred to the Punjab in April last, to take up a similar appointment there.

Mr. Ganpatlal Dayashanker Mehta, L.Ag., B.A., N.D.A., N.D.D., late of the Bombay Agricultural Department, was appointed Supernumerary Agriculturist on 4th June, 1911, and has been on deputation under the Bombay Government at Poona.

Mr. Judah Hyam, Veterinary Overseer, continued in charge of the breeding herds. He obtained three months' leave from July to October during which period Mr. L. S. Joseph officiated for him.

Messrs. Md. Ikramuddin and Md. Ziauddin Hyder held the appointments of Farm Overseers throughout the year. Mr. Ikramuddin arranged the camps of the Board of Agriculture and of the Tirhut Agricultural Show at Pusa, and his services in this connection were acknowledged by both bodies.

Mr. Nizamuddin Hyder of the staff of the Inspector General of Agriculture had charge of the poultry-breeding experiments until 26th October 1911, when he reverted to his original post on the staff of the Fibre Expert to the Government of Eastern Bengal and Assam. Mr. Ali Murtaza, Fieldman, was appointed in his place.

2. *Training.*—Mr. M. Fatehuddin, B.A., Assistant Director of Agriculture, Punjab, completed his two years' course of training in general agriculture on 21st August, 1911, and returned to the Punjab.

Three students attended the short courses on Cattle-breeding and Poultry management.

3. *Character of the Season.*—The rainfall during the year amounted to 56·30″. The monsoon arrived early and gave copious rainfall throughout its duration. Three severe floods damaged the kharif crops considerably and a late flood retarded the sowings of the rabi crop. The oat crop sustained some damage through late winter rains.

4. *Cropping.*—The following is a list of crops grown :—barley, oats, wheat, castor, bhindi, sugar-cane, jute, rice, maize, arhar (*Cajanus indicus*). Other crops grown on small plots for the Entomological Section included a number of millets and pulses.

5. *Cattle-breeding Herd.*—The numbers of the breeding herd are as follows :—

	Cows 74,	Bulls 5,	Young stock 118	
against	„ 69,	„ 3,	„ „	105 in 1911

Eleven cows, one bull and 19 young cattle have been sold during the year.

An outbreak of Foot and Mouth Disease in August 1911 caused the death of nine of the young stock. There was, however, no mortality in the milking herd from this cause. Three cases (all fatal) of black quarter occurred in June of this year. The Veterinary Overseer is to be congratulated on the prompt and successful measures undertaken to prevent an epidemic of this disease. The local Veterinary Department rendered valuable assistance in preventive inoculation.

6. *Sheep.*—The Gorakhpur sheep continue to do well. Dumbha rams are still used for crossing. The progeny will be used as a basis for the further improvement of wool production.

7. *Pastures.*—As indicated in last year's report a 4-acre plot was laid down to permanent pasture after a green manure.

8. *Clearing and Levelling.*—Roads have been constructed in the low-lying brick-field area and a portion of the waste land reclaimed.

9. *Fodder.*—The economic value of guinea grass as a fodder has been established and returns up to 350 maunds per acre obtained.

10. *Implements and Machinery.*—The wheat and oat crops were mostly cut by machines. The futility of a short cutting bar was demonstrated by the average daily work of two machines, *viz.*:—

A.	4½ ft. cut	5½ acres per day.
B.	3 „	3 „ „

The general cultivation has been much improved by the use of light ploughs of the Rajah and Punjab types which suit local conditions.

Spring toothed harrows have been found useful in preparing land for crops and maintaining summer fallows.

11. *Experiments.*—The following experiments are in progress and will be continued—

(*1*) The permanent manurial and rotation experiments started in 1908.

(*2*) The improvement of the sugar-cane crop by trenching, earthing up and intertillage.

(*3*) Experiments with regard to the sprouting of sugar-cane sets. A promising start was made last year by steeping the sets in water at 100° F.

(*4*) The application of crude sulphate of soda to paddy. An increase of 17 maunds of grain per acre on a 5-acre experiment was obtained last year. This preliminary result requires confirmation as information regarding the uniformity of the plots treated was not complete.

12. *Poultry.*—The following 5 out of 31 breeds imported and put under trial have been selected as suitable for the country and for crossing purposes :—

(1) Buff Orpington.
(2) White Wyandotte.
(3) Chittagong.
(4) Lakha Game.
(5) Mammoth Bronze Turkeys.

Owing to the rejection of unsuitable breeds, the general condition of the birds has shown a great improvement on previous years.

13. Programme of work for 1912-13.

In addition to the permanent experiments recorded above the following will be undertaken :—

General.—The organization of the estate work has been recently altered and the fieldmen now hold charge of independent sections. It is hoped that a more intimate acquaintance with the varying soil conditions will be made possible.

The large low-lying brick-field area will be further subdivided by roads. A good deal of levelling remains to be done before much detailed field experimenting can be undertaken, but this work will be pushed on as rapidly as possible.

Cropping.—A great improvement has been made in the general cultivation by the adoption of regular rotations. A special study of the maintenance of the fertility of the soil under the rotation and system of manuring adopted will be made. This system includes a dressing of superphosphate applied directly to a green manure. Quantitative estimates of the artificial manures necessary and the period of application will be made.

Field experiments have been started in collaboration with the Imperial Agricultural Bacteriologist to gain in-

formation regarding the decomposition of green manures under varying conditions of—

(*a*) Water content of the soil,
(*b*) Air content of the soil,
(*c*) Age of plant at time of burying,
(*d*) Depth of burying,

and as to the effect of such manures on the condition of the soil.

Cultivation.—Special investigations as to the value of intertillage by bullock implements in maize and sugar-cane will be undertaken. Correct spacings for maize both as a fodder and grain crop will be studied.

An improvement in the methods of working the heavier low-lying land appears to be necessary and improved implements will be given a trial.

Breeding Herd.—The present Montgomery herd is doing satisfactorily, although the milk yield is not as high as might be desired. Owing to the demand for milk from the subordinate staff and the want of budget provision for extensive purchases a rigid selection of the best milking cows has not been possible. This tends to keep down the average yields. Line breeding will be necessary as pedigree cattle of this breed are not obtainable in the country.

Sheep.—The young Gorakhpur Dumbha cross ewes will be used as a foundation for further improvements in wool production. It seems necessary to investigate what type of fleece is the most suitable for sheep in the plains of Northern India, whether a loose coat with a good length of staple or a close fine coat. It is also necessary to regularize and limit the lambing period, to cast the ewes at regular ages, and to employ a more rigid selection as regards wool.

Pastures.—A study of the agricultural characters of pasture grasses and legumes will be undertaken with a view to the sowing of mixtures instead of pure cultures of *dubh*. The effect of rolling, harrowing and topping pastures will

be noted. The rough river-side grazing areas will be systematically cut and grazed with the object of their ultimate improvement. The question of the cheapening of the present methods of laying out of land to pasture will be taken up.

REPORT OF THE IMPERIAL AGRICULTURAL CHEMIST.

(J. WALTER LEATHER, PH.D., F.I.C., F.C.S.)

1. *Charge and Establishment.*—This section was in the charge of myself during the whole year.

Mr. H. E. Annett, Supernumerary Agricultural Chemist, returned to duty at Pusa on 6th November 1911 from Cawnpore, where he had been acting as Principal of the Agricultural College. He left Pusa again on May 9th, 1912, to act as Agricultural Chemist, Punjab.

Mr. Bhailal Motibhai Amin has continued on deputation at the Sirseah Indigo Research Station. Babus Narain Lal Tewari and Narendra Nath Mitra, M.Sc. (All.), are the two new assistants, who have been appointed to fill vacancies which had occurred.

2. *Meteorology.*—In addition to the usual meteorological observations which are submitted to the Meteorological Department monthly, records are maintained of (*i*) pressure by means of a barograph, (*ii*) soil temperatures at depths of 1 in. down to 2 ft. from the land surface by means of maximum and minimum thermometers, and (*iii*) evaporation from a plain water surface.

3. *Drainage Data.*—The amount of water which drains annually from fallow land and from land bearing crops is determined at Pusa and at Cawnpore by means of gauges, descriptions of which have been published.* The water is analysed regularly in regard to certain constituents, such as nitrogen compounds and mineral matters. The records of the first few years have been published as a Memoir† of this Department. The chief deductions admissible from these records were detailed in my last annual report.

* Annual Report of Cawnpore Farm, 1905-06, page 23, and Memoir of the Department of Agriculture in India, Chemical Series, Vol. I, No. 5.

† Memoir of the Department of Agriculture in India, Chemical Series, Vol. II, No. 2.

Among the observations made was that not only was there less nitrate in the drainage water from the cropped soil than from the fallow land, but that the deficiency could not be accounted for merely by assimilation by the crop. Either less nitrate was formed in the presence of the crop or some other agent than the crop was assimilating the nitrate. The crops had been wheat and maize at Pusa. In order to test if a like result is obtainable when other crops are grown, the maize has been replaced by sunn hemp; and wheat is grown in rotation on one gauge only. In this manner it is hoped to ascertain whether there is a deficiency of nitrate in the drainage water from this system of cropping as there was from the wheat-maize.

Reference was also made in my last report to estimations of nitrate in fallow land throughout the season. These were continued last monsoon and cold weather and will be repeated during the coming cold weather.

4. *The Water Requirements of Crops.*—Work was continued on this subject during last cold weather, more especially with reference to the transpiration ratio of crops grown in the Cawnpore soil. This soil had not been employed previously in the pot-culture experiments at Pusa and also the field experiments at Cawnpore had been interfered with by bad seasons. The pot-cultures yielded ratios very similar to what had been obtained in other soils. The field plots yielded results which differed from those at Pusa chiefly in the fact that the soil moisture was drawn upon by the plant from a greater depth than was the case at Pusa.

5. *Soils. Usar.*—The nature of the work on *usar* soil in the United Provinces has been indicated in previous reports, and especially in my last year's report. The examination of the soils taken from alkali spots in the Muttra and Etah Districts left no doubt that these alkali spots are identical in character whether they occur under well or under canal irrigation. The experiments which have been in progress at Pusa on some soil which was taken originally

from good land closely contiguous to alkali land, and which were designed to demonstrate whether such soil would become *usar* if maintained in a water-logged state, have not so far yielded a definite answer. Both soils were examined after being under experiment for two years, and one was apparently still quite good; in respect of the other there was a doubt as to whether it had changed somewhat.

The whole series of tests were reported upon to the Director of Land Records and Agriculture and to the Chief Engineer, Irrigation Branch, United Provinces.

A series of samples of soil from Quetta were submitted to me for examination by the Irrigation Officer in Baluchistan, the question being whether irrigation was causing the lands to become saline. It was known from analyses made by me in 1909 how very saline the water of the Sheboo canal frequently is, and there is a natural suspicion that irrigation with it must lead to an accumulation of salts in the soil. The examination of the soils showed that in three cases out of four the irrigated land was less readily permeable to water than the unirrigated, and in two cases the irrigated land contained rather more salts. The difficulty in making a reliable deduction in questions such as this lies in the fact that the changes which may be going on are only slow and hence frequently difficult to detect.

6. *Saltpetre.*—Further experiments were made during the year on an improved method for refining crude saltpetre. The filter, which had worked very well at the Allahabad Exhibition, proved, when made of a considerably larger size, to be defective, and experiments are now being conducted with another class of filter which it is hoped will be more efficient. The refined saltpetre was sold in Calcutta without any difficulty at full market rates.

7. *Sugar.*—Work on sugar during the past year has included (*i*) an examination of the date sugar industry, (*ii*) testing the effect of removal of cobs from maize which results in an accumulation of sugar in the stem, (*iii*) estimating the error which is involved in sampling sugar-cane,

and (*iv*) an examination of sugar beet roots which were grown near Peshawar.

8. *The Date Palm Sugar Industry.*—As mentioned in my last annual report, an investigation of the date palm sugar industry was commenced at my suggestion by Mr. Annett during the cold weather of 1910-11. This was continued during the cold weather of 1911-12 and has resulted in an accumulation of some very valuable information on the subject. In addition to a review of its past history, Mr. Annett has been able, by spending some months in the Jessore District, to obtain an intimate knowledge of the present conditions of the industry, its agriculture, mode of cultivation, tapping, and manufacture of the raw and refined sugars. Also he conducted a long series of tests in camp in Jessore on the quantity and composition of the juice, the amount of decomposition and the means by which this might be prevented. Mr. Annett found that the fresh juice contains 8 to 10 per cent. of sucrose associated with practically no glucose, but that owing to imperfect methods of collection, 1 to 2 per cent. of glucose is formed during the night. There are also subsequently further losses of sugar during the boiling process, which is at present carried out in small earthen pots, and again during the native refining processes losses of sugar occur. In an account of this work, which is to be published, Mr. Annett refers to the great improvements which have been introduced into the corresponding American industry—the maple sugar manufacture—in which case it is to be noted that a juice containing only some 3 per cent. of sugar forms the "raw material." If one can afford to employ good appliances and perfected methods in that industry, it should certainly be possible to apply them to India's date sugar.

The reference to this investigation would be incomplete without an acknowledgment to Mr. E. G. McLeod of Kotechandpur, who rendered Mr. Annett very considerable assistance and provided him with detailed information of the profits and losses of his (Mr. McLeod's) factory.

9. *De-cobbing Maize Plants.*—Several Agricultural Journals* have contained notes on the effect of removing the cobs from maize plants prior to fertilisation by the pollen, this process being said to result in an accumulation of sugar in the stem. Experiments were made by Mr. A. C. Dobbs, Assistant Inspector General of Agriculture, during last monsoon period in order to test the effect of the process and to ascertain whether it would prove itself a useful one. Analyses of the plants showed that an increase of sugar (sucrose) did occur; in one case the cane sugar rose from 2 per cent. to 9 per cent., the percentage referring to the weight of stem, but the process was not considered on the whole to be an economical one.

10. *Experimental Error in Sampling Sugar-cane.*—It will be readily appreciated that when a sample of cane is taken from a field which is supposed to represent the whole, an error is involved, and the examination of the sample will not show the average composition of the whole but will depart from the true value to a greater or less degree. It is also obvious that not only is a knowledge of the magnitude of this error of importance, but also that it is very desirable to know how to take a sample of sugar-cane in order to free the result of such errors as far as possible.

Some tests were made in 1910 and again this year with the sugar-cane crop which were designed to elucidate the subject, but it will be necessary to carry out a third series of tests during the coming season in order to arrive at definite conclusions. In illustration it may be mentioned that if a sample of 3 or 6 canes is taken from a field the "probable error" is about 1 per cent. to 2 per cent. in the sucrose determination. By taking more and more canes in the "sample" the error becomes naturally smaller, but even if one-fourth of the crop of a $\frac{1}{10}$-acre plot be crushed, an appreciable error still remains, and one-fourth of such a crop is a large quantity of cane. It is the size of the smallest necessary sample to be taken in order to secure an

* Agricultural Journal of the Union of South Africa, Vol. I, No. 4, p. 540. Agricultural News, Vol. X, No. 234, p. 115.

error less than a certain magnitude that we desire to estimate.

11. *Sugar Beet Roots.*—Some samples of sugar beets which had been grown near Peshawar by the Superintendent of Farms were examined and the result is of interest because one lot included beets of a high grade. The percentage of sucrose varied in this lot between 17 per cent. and 20 per cent. of sucrose in the juice, demonstrating that very good sugar beet could be grown in Northern India if desired.

12. *Milk.*—In co-operation with Mr. A. C. Dobbs a series of tests were made during the year on the quantity and composition of the milk of the Montgomery herd at Pusa which have led to some interesting results. The work will not be completed until next year, but the following will indicate its nature.

When testing cows' milk in India two sources of error must be guarded against: (*i*) if the periods between milking are not equal the composition of the milk will be influenced, and (*ii*) the calf takes an indefinite quantity of the milk unless this is specially controlled. In order to eliminate these sources of error the cows were milked at 12 hour intervals, and the calf allowed to take the whole of the milk from only one side of the udder, the other half being milked by hand. The cows were milked by hand for 24 hours on (say) the right hand side of the udder whilst the calf took the milk from the left hand side, and then during the succeeding 24 hours the left side would be hand-milked, whilst the calf took milk from the right side. Moreover the diurnal change from the right hand side to the left hand side was made in the morning for one month, and in the evening during the next month. During one period of two months the milk of the fore and hind quarters of the udder of three cows was separately examined.

By these means great regularity was obtained in the composition of the milk and several characteristic differences were observed. The most prominent was the difference between the percentage of fat in the morning and evening milk; the former always contained from ·5 to 1·5 per

cent. more than the latter; the difference was greater with some than with other cows, but no cow was an exception to the rule. No *systematic* difference was found in the composition of the milk of the one side of the udder and the other side, but a *systematic* difference was observed with two cows in the composition of the milk of the fore quarter udder and hind quarter respectively. This latter point was tested with only three cows, so that whether this is a common or an exceptional characteristic of the cows is not yet known. The percentage of fat in the milk of this herd has been about 4 to 5 per cent. in the morning and 3 to 4 per cent. in the evening, which is less than has been found for Sind and Gir cows at Poona.

Regarding the *yield* of milk this was found to be from 5 to 6 lbs. per day *obtained by hand*, to which must be added the like quantity taken by the calf, making 10 to 12 lbs. or say 5 to 6 seers daily which is also less than what the Sind and Gir cows yield.

13. *Education.*—There are at present five students in this section; three of these being Government stipendiary students, one each from Bengal, Bihar and Orissa and Travancore; and two private students. One of the students mentioned in my last report was considered not likely to prove himself an efficient assistant and he was consequently not permitted to complete his full course of study. One student of the Entomological Section took a special course of photography.

14. Programme of work for 1912-13.

1. The work on the availability of plant food in soils will be continued.

2. In the current work on the moisture requirements of crops, the effect of different proportions of moisture in various soils for various crops is being ascertained.

3. The investigation of the chemistry and manufacture of date palm sugar will be continued.

4. Experiments on possible improvements in the manufacture of saltpetre will be continued.

5. The experimental error in sampling sugar-cane is being ascertained.

6. The effect of certain factors, such as climatic changes, time of milking, etc., on the composition of cow's milk, is being investigated.

7. *Education.*—This requires no special comment and will be conducted according to the lines laid down.

16. Publications.

The following papers have been published :—

1. "*Records of Drainage in India.*"—Memoir of the Department of Agriculture in India, Chemical Series, Vol. II, No. 2, January 1912.
2. "*Flow of Water and Air through Soils.*"—Journal of Agricultural Science, Vol. IV, Part 3.
3. *The effect of* (i) *alkali and* (ii) *impermeability in soils on plant growth.*—(VIII International Congress of Applied Chemistry.)
4. *Method for the determination of the rate of percolation of water through soils.*—(VIII International Congress of Applied Chemistry.)
5. *Report on Industrial and Agricultural Chemistry* for the Board of Scientific Advice (by Messrs. Leather, Hooper and Puran Singh).
6. *Date Palm Sugar.*—Memoir of the Department of Agriculture in India (*in the press*).

REPORT OF THE IMPERIAL ECONOMIC BOTANIST.

(A. HOWARD, M.A., A.R.C.S., F.L.S.)

Part I.

TEACHING, TRAINING AND STAFF.

Charge.—I held charge of the section at Pusa during the period under review, namely, the year ending June 30th, 1912.

Students.—One advanced student from the Agricultural Department of the Central Provinces worked in the section from October 1st, 1911 to the end of April 1912. This student made considerable progress in spite of his want of familiarity with growing crops.

Staff.—The appointment of a Personal Assistant has very materially facilitated the working of the section and, at the same time, has greatly increased the volume of results obtained. During the months July to September 1911 and during May and June of 1912, when I was at Quetta, the Second Assistant, Moulvi Abdur Rahman Khan, was in charge of current work at Pusa and I have pleasure in reporting that he carried out his duties in a very satisfactory manner. The monsoon season of 1911 was a difficult one due to the excessive rainfall, but in spite of this the tobacco crop was good and the rest of the land in the botanical area compared favourably with anything I saw in the neighbourhood on my return to Pusa at the end of September. The work of the rest of the staff was satisfactory.

Part II.

WHEAT INVESTIGATIONS.

The wheat investigations at Pusa have been extended during the past year and results of considerable value have been obtained.

Trials of Pusa Wheats in India.

During the *rabi* season of 1911-12 extensive trials of wheats were made in most of the important wheat tracts of India. As these trials have, in many cases, passed the experimental stage and the wheats are being grown on a large scale for seed distribution, the present seems a fitting opportunity of summing up the results so far obtained and of giving a connected idea of this portion of the wheat investigations.

One of the first results of the wheat investigations at Pusa was the demonstration of the fact that varieties with milling and baking qualities similar to those of the best wheats on the English market could be grown to perfection in Bihar under *barani* conditions. By the application of modern methods of selection and hybridization these high grain qualities were successfully combined with high yielding power, rust-resistance and strong straw so that wheats were produced which gave upwards of 2,500 lbs. of grain to the acre without irrigation or manure. In one case, a yield of 2,832 lbs. to the acre was obtained at Pusa. These new wheats were then thoroughly tested in England, both in the mill and bakehouse, and were found to behave like Manitoba spring wheats, which are in greatest demand for bread-making in England and which command the highest prices on the Home markets. In this portion of the work I was fortunate enough to secure the co-operation of Mr. A. E. Humphries, a past President of the Incorporated Society of British and Irish Millers.

The next stage in these investigations was to extend the trials to other wheat-growing areas in India. These were carried out during the *rabi* seasons of 1910-11 and 1911-12 and the results are summed up below.

United Provinces.—As most of the wheat exported from India is grown under irrigation, it was important to ascertain by actual trials whether high grain quality and high yield could also be obtained under canal irrigation. Fortunately in this portion of the investigations the active co-operation of Mr. H. Martin Leake (Economic Botanist

to the Government of the United Provinces) was secured and extended trials of the Pusa wheats have been carried out during the past three years at Cawnpore. The results obtained were most satisfactory. In the first place, it was found that yields over 2,200 lbs. per acre and in one case as high as 2,500 lbs. could be obtained with one watering, that is, with one-third the water usually employed by the cultivators in the neighbourhood. In the second place, the appearance and milling and baking qualities of the wheats were at least equal to those grown at Pusa under *barani* conditions. This was the verdict of Mr. Humphries, who, in 1911, tested the same kinds grown at Cawnpore under canal irrigation and at Pusa as a dry crop. During the last *rabi* season, one of the Pusa wheats was grown at Cawnpore without any irrigation water at all and a yield of 1,650 lbs. to the acre was obtained, a remarkable result in a canal-irrigated tract.

The Cawnpore trials, which had extended over three seasons and which were uniformly successful, were repeated on a small scale on the Aligarh Farm in 1910-11 and again in 1911-12 on a large scale by Dr. Parr, Deputy Director of Agriculture. The yields obtained during the last season are given in the table below.

Trial of Pusa wheat at Aligarh, 1911-12.

Name.	Yield in lbs. per acre.
Pusa 22	2,098
Pusa 8	2,139
Pusa 12	2,510

During the last *rabi* season the Pusa wheats have been grown on a considerable scale by the tenants of the Court

of Wards Estates in the District of Kheri. The following are some of the results obtained by these cultivators :—

Results of the Pusa wheats grown by ryots under the Court of Wards Estate, Kheri.

Name of wheat.	Name of estate or circle.	Previous treatment of land.	Yield per acre in lbs.
Pusa 12	Kaimalua	Unmanured	2,222
Pusa 12	Rajapore	Ditto	1,619
Pusa 101	Mankapore	Ditto	2,057
	Bhulanpore	Ditto	1,935
	Amirtaganj	Manured	1,285
	Rasulpanah	Ditto	1,563
	Tendhua	Ditto	1,234

It will be seen that in the United Provinces the trials have extended over three years at Cawnpore and two years at Aligarh and the wheats have also been grown by cultivators. In all cases they have been successful.

Punjab.—At the Gurdaspur Experiment Station in the Punjab during the past wheat season, the following results were obtained under strict *barani* conditions on unmanured land by Mr. Milligan, the Deputy Director of Agriculture. These results are the immediate outcome of the application of improved methods of wheat growing to the *barani* tracts of the Punjab.

No.	Grain in lbs. per acre.	Bhusa in lbs. per acre.
Pusa 12	2,122	3,989

On the canal-irrigated tracts of this Province the methods of growing the crop to perfection, which have

proved so successful at Cawnpore and Aligarh, have not yet been worked out. One point, however, has been demonstrated. In 1911, it was found that high quality Pusa wheats grown by tenants of the Lyallpur Farm retained their milling and baking qualities. There is every hope that provided proper care is taken in cultivation and in the use of irrigation water, results similar to those of Cawnpore can be obtained in the Canal Colonies of this Province.

Central Provinces.—As the soil conditions of the wheat-growing tracts of Peninsular India are quite different from those of the alluvium of the Indo-Gangetic plain it appeared probable that the Pusa wheats, most likely to be suitable for the black soils of the Central Provinces, would be found among the rapidly maturing varieties. Accordingly, these have been tested at Tharsa and Raipur by Mr. Clouston and one kind was tried on a small scale at Hoshangabad this year by Mr. Evans. The results are given below.

Trial of Pusa wheats, 1911-12, in the Central Provinces.

Name.	Yield per acre.	Remarks.
Pusa 12 . .	885	
Pusa 107 .	769	
Pusa 108 . .	750	
Pusa 4 . .	645	Damaged by hail.

The yield of the local kinds in the Central Provinces rarely exceeds 600 lbs. per acre and both at Tharsa and Raipur the Pusa wheats gave a larger outturn than any of the other varieties tried, while in rust resistance and grain quality they proved distinctly superior.

As regards the quality of the Pusa wheats grown in the Central Provinces, one, Pusa 4, was in 1911 tested in England by Mr. Humphries who reported: "The Raipur unirrigated lot is truly superb in appearance, indeed I do

not think I am exaggerating if I say it is the finest looking lot of Indian wheat I have ever seen." As regards the bread made from this wheat Mr. Humphries said : " In hue and general appearance of crust and crumb the Raipur lots are of the very highest class, but on the one point of strength they are really good without being extraordinary, judged by the standard of typical London flour." These opinions were confirmed by Messrs. Ralli Brothers, who valued Pusa 4 higher than any of the large collection of Indian wheats grown at Raipur in 1911. It is probable that this wheat will be of the greatest use in the Central Provinces on light soils and in years when the soil moisture is short as it ripens in the second half of February and fully a month before the local wheats. Next year it is being tried by Mr. Evans in the Jubbulpore District where a rapidly maturing late sown wheat is required on the embanked wheat lands.

Bihar.—The first trial of Pusa wheats in Bihar was made at Mia Chapra Estate in 1909-10 when 1,975 lbs. to the acre of Pusa 20 were obtained after maize the same year. All the seed was sown the following year on this estate and the resulting crop was disposed of at Rs. 5 per maund as seed wheat.

In 1910-11, several other estates grew Pusa wheats on a small scale and in all cases the yield was greatly in excess of that given by country seed. The success of these trials on a small scale led to a great demand for seed after the harvest of 1911.

During the past season, the trials were considerably extended and about 1,500 acres of land were sown with the new wheats. Some of the results are to be found in the following table and on the average the yields obtained are at least twice that given by the local wheats. The growers are very pleased with the results and are keeping the bulk of their harvest to sow an extended area next year. It is anticipated that between 10,000 and 15,000 acres will be sown with Pusa wheats next year.

Trial of Pusa wheats in Bihar in 1911-12.

Name of wheat.	Name of Factory.	Type of soil.	Yield per acre in lbs.	Remarks.
Pusa 20 .	Bowarrah Concern .	1st class wheat land.	1,975	
	Ditto .	2nd class wheat land.	1,483	
	Mia Chapra Concern, 1909-10.	1st class wheat land.	1,975	
	Mia Chapra Concern, 1911-12.	Do.	2,468	
	Belsund Concern .	Medium .	1,619	
	Bowarrah Concern .	Fairly heavy	1,240	
Pusa 6 .	Motihari Concern .	Light loam .	1,839	
	Belsund Concern .	Medium .	1,730	
Pusa 8 .	Hathowri Concern .	1st class wheat land.	2,017	
	Munjhoul Concern .	Light .	1,218	The Manager states that the soil was too light for wheat.
Pusa 12 .	Mooktapore Concern	Medium .	1,481	Patna wheat sown in the same field gave only 1,028 lbs.
	Rewari Concern, 1910-11.	Land seethed	1,199	Late sowing affected the yield.
	Bogwanpore Concern	Light . .	1,234	Badly attacked by white-ants.
Pusa 8 and 12 mixed.	Motihari Concern .	Light loam .	1,693	Yield affected by laying due to storms.
Pusa 101 .	Bogwanpore Concern	Light . .	1,234	Badly attacked by white-ants.
	Jugolia Concern .	*Mattar* green manured.	1,351	Wheat laid and consequently yield affected by over-manuring.

Trials of Pusa wheats in Bihar in 1911-12 —contd.

Name of wheat.	Name of Factory.	Type of soil.	Yield per acre in lbs.	Remarks.
Pusa 104 .	Belsund Concern .	Poor . .	1,451	The Manager estimates the yield would have equalled Pusa 105 if land had been good.
Pusa 105 .	Belsund Concern .	..	1,798	
Pusa 106 .	Hathowri Concern .	1st class wheat land.	1,880	Damaged by rain and rats or yield would have been still greater.
	Birowlie Concern .	2nd class wheat land.	1,707	
	Motihari Concern .	Light loam .	1,460	
	Dholi Concern .	Light land somewhat poor.	1,174	Local wheat in adjoining field gave less than half this yield.
	Mia Chapra Concern	Medium .	1,645	
	Bogwanpore Concern	Light . .	1,234	Crop badly attacked by white-ants.
	Mooktapore Concern	Medium .	1,480	Damaged by water-logging; local wheat gave two-thirds this yield in the same field.
	Belsund Concern .	Light .	1,139	Sown on soil too light for this wheat.

All the land was unmanured unless otherwise stated.

Owing to the abnormally heavy and late "hathia" rains in 1911-12 most of the wheat in Bihar had to be sown on light or second class wheat lands as the first class wheat lands did not dry in time to plough. Much of the wheat was also sown on a wet seed bed. The yield of wheat this year at Pusa, owing to the late October rains, averaged

1,600 to 2,000 lbs. an acre instead of the usual 2,000 to 2,500 lbs.

Cultivation Experiments.—Another aspect of the wheat investigations at Pusa should be mentioned. This relates to the importance of hot-weather cultivation, clean culture and moisture conservation in crop production in the Indo-Gangetic plain. By applying the methods of cultivation, which have been found successful for wheat, to other crops, both *kharif* and *rabi*, greatly increased crops are easily possible. The Pusa results have already attracted great attention in India to improved methods of cultivation and moisture conservation and have thus been of direct use in showing one of the directions in which the land, now under crops in the plains, can be made to produce much heavier outturns. The effect of these methods is cumulative and the highest yields are not obtained till the second or the third year. The methods of cultivation referred to have been published in detail in Pusa Bulletin No. 22 and Urdu and Hindi versions have also been issued. Of these latter a second edition has been called for by Mr. Burt, Deputy Director of Agriculture, for distribution in the Central Circle of the United Provinces.

Seed Distribution.

As a result of the successful trials of the new wheats in various parts of India a great demand for seed has arisen during the past year which could only in part be met. Arrangements, however, have been made to grow a large stock of seed during the coming season which it is hoped will be sufficient for all purposes.

The seed distribution arrangements in Bihar arose out of the demonstration in wheat growing given in connection with the Tirhut Agricultural Exhibition held at Pusa in January last. After this show the Bihar Planters' Association suggested the immediate formation of seed farms on estates under my supervision so as to supply a large amount of seed wheat yearly. This has been done and about 1,000 acres of the new wheats will be sown on

three estates next year for seed purposes. This arrangement ensures the expansion of the work at practically no cost to Government while the estates where the crop is grown to perfection will also serve as demonstration areas and local seed farms for the cultivators in the neighbourhood. The various wheats grown will be maintained at Pusa in pure culture and whenever necessary the seed farms will be re-stocked with fresh seed.

In the United Provinces the distribution of seed is being carried out under the direction of Mr. Leake who has arranged to grow about one hundred acres at Cawnpore and Aligarh.

In the Central Provinces the work of seed distribution is in the hands of Mr. Clouston, the Deputy Director of Agriculture, who is growing Pusa wheats on a large scale at Raipur and Tharsa. Mr. Evans proposes to try one of the early maturing wheats (No. 4) in the Jubbulpore District.

At Pusa, during the past year, the amount of the seed distributed from the botanical area was 250 maunds. In future the chief work at this centre will be confined to keeping the various kinds pure and to growing sufficient seed for demonstration purposes and for re-stocking periodically the various seed farms. In addition, a considerable area of wheat land will be taken up by the numerous cultures in connection with the selection and hybridization work in progress and with variety trials.

The Influence of the Environment on Quality.

An important stage has been reached in the experiments on the influence of environment on the milling and baking qualities of wheat. These investigations are being conducted in collaboration with Mr. Leake and the results obtained up to the *rabi* season of 1910-11 have been incorporated in a paper which is now being printed. The object of these experiments is to discover to what extent high quality in grain is possible in the various wheat-growing tracts of India and for this purpose various pure lines

have been grown at a large number of stations and the produce tested. If wheat of good quality can be grown in any tract this fact is of great importance in the work of improvement as practically all the Indian wheats of commerce are poor in quality.

The principal result obtained during the year is the demonstration of the fact that wheats of good quality can be grown under canal irrigation in the alluvium and also on the black cotton soils of Peninsular India. Quality in wheat in India is not confined to the *barani* crop. Indeed at Cawnpore during the past year the samples produced under canal irrigation were better than the same wheats grown at Pusa. At Raipur, on the black cotton soil, the samples of Pusa 4 were certainly finer than that produced the same year at Pusa. Even when grown after rice and at Lyallpur by poor cultivators the wheats did not lose their milling and baking qualities.

The results with Muzaffarnagar, a soft weak wheat, obtained at the various stations are also of interest. In no case did this wheat show strength although its milling and baking qualities were improved by the cultivation it received at Cawnpore and Pusa.

These experiments also throw considerable light on the relation between yield and quality in wheat. It was found that, in any particular wheat, the conditions which produce the highest yield are those which also produce the best quality. Further, in the same wheat, high yield and high quality can be combined. A cultivator therefore, who wishes to obtain the greatest financial return for his labour, should grow to perfection a wheat which combines high yield and good grain qualities. When this is accomplished, Indian wheats will be second to none in the markets of the world.

In this portion of the work a large number of milling and baking tests were necessary. These were carried out by Mr. Humphries in England and it is fortunate that his invaluable assistance was secured. Dr. Leather kindly

undertook the large number of nitrogen determinations involved in these investigations.

Cultivation Experiments at Pusa.

In connection with the growth of wheat at Pusa several matters connected with the cultivation of the crop have been observed which have since been made the subject of experiment.

The first concerns the continuous growth of wheat without manure. This experiment is being conducted on a plot of typical wheat land, which is heavy in texture and which retains water well. The past season was the fifth year of the experiment and the yield was twenty-six maunds to the acre, an increase on that of previous years. This is the limit of the yielding power, up to the present at Pusa, of the variety grown on this plot and the results show that, after five years' cropping with wheat without manure, the natural fertility of the land is not yet affected. Indeed, the last crop was much too rank and was laid to a considerable extent by wind after coming into ear.

The next cultivation experiment is concerned with the effect of hot weather cultivation as compared with late ploughing after the beginning of the monsoon. This experiment is now in the second year and last season the difference in yield between the two plots was twelve and a half bushels to the acre in favour of early ploughing. In the first year, the difference was only six bushels, due to the fact that both plots started in a high state of cultivation. This result appears to indicate that the effect of hot weather cultivation is cumulative and that the maximum yields are not realised the first year.

Drainage is an important factor in wheat growing in the alluvium and influences both the yield and the quality. On waterlogged areas, the consistency of the sample is generally very mixed and the yield is low. An experiment on this subject at Pusa showed that waterlogging the land during the month of September previous to sowing reduced the crop fifty per cent., that is, to sixteen bushels to the acre. This was shown to be due to a want of available nitrogen,

caused no doubt by a change in the soil flora due to the waterlogging and want of air. A rice land condition seemed to have been set up in which the wheat crop did not thrive. The subject of the importance of drainage was brought to the notice of the Bihar Planters in February last in a paper read before the Association at Mozafferpore.

Breeding.

During the year a considerable amount of attention has been devoted to wheat breeding, particularly with regard to the production of new rust-resistant wheats with high yielding power and strong straw. In connection with these investigations, which have been designed to secure results of immediate practical value, some interesting facts dealing with the inheritance of characters in wheat have been elucidated. A paper on this part of the subject is in course of publication. These results, which at first sight appear to be only of theoretical interest, are in reality of practical value as they show that the gametic constitution of wheats must be known with certainty before they can be used as parents for the production of new types. Further it is desirable that all varieties of crops in India (whose behaviour in breeding is known) should be most carefully preserved at the experiment stations so that they may be immediately available for other workers.

The new experiment station at Quetta was of use in connection with the breeding work at Pusa. The variety trials in 1912 indicated that two crosses on the pure line A 88 were desirable. This could only be seen at harvest time when it was too late to make the crosses. Seed was, however, sent to Quetta in March and the crosses were made in the following June thus saving a whole year in the work

Part III.

OTHER INVESTIGATIONS.

Tobacco.

The progress reported in the previous annual report with regard to this crop has been continued during the past year.

Cultivation.—The successful growth of this crop after a green crop of *san* ploughed in was referred to in last year's report. This method of manuring was repeated on a large scale in 1911-12 and in spite of the bad season a very good crop was produced. The excessive rain at sowing time in August, followed by long continued wet weather till the middle of October, greatly interfered with the preparation for this crop. In consequence, the growth was slow and the period of ripening delayed. Even under these adverse conditions, the crop grown on *san* was superior to any tobacco fields in the neighbourhood.

Curing.—The curing experiments of the previous year were repeated on a large scale, the crop being grown after *san* ploughed in without any other manure. Three types, Nos. 28, 29 and 32, were grown and cured by a modification of the country method, care being taken to use the minimum amount of moisture in the process so as to preserve the yellow colour as much as possible. Type 28 gives a yellow colour combined with good texture and fine leaves and was reported on very favourably in 1910-11. Types 29 and 32 are heavier, coarser kinds with darker colour and large leaves. These were grown for comparison with Type 28. The whole of the crop was sent to the Peninsular Tobacco Company at Monghyr and made into cigarettes. Type 28 again received a very favourable report and the leaves were valued at Rs. 12 to Rs. 14 per maund which is a considerable advance on the local prices. A large quantity of self-fertilized seed of this type was grown for the Company and arrangements have been made on three estates to grow this kind next year. The results obtained with this tobacco show that a suitable leaf for cigarettes can be grown and cured in Bihar by the people and thus the first object of these curing experiments has been achieved. It now remains to get the Pusa results repeated on the indigo estates and to see whether the planters in Bihar are prepared to take the trouble necessary to grow and cure this tobacco. If they do it will then be possible to consider whether or

not fire curing in some simple form in earth-built barns can be undertaken in Bihar with any prospect of success.

Breeding.—Considerable progress was made during the year by the Personal Assistant in the investigations on the inheritance of characters in *Nicotiana tabacum* and in *N. rustica*. The object of this work is to discover the mode of inheritance of the various leaf characters in particular so that new and improved varieties can be produced by hybridization. The results so far obtained are now being submitted for publication.

It is interesting to note that the earlier selection work done on the tobacco crop at Pusa and published in Nos. I and II of the third volume of the Botanical Memoirs has been repeated by the Bureau of Plant Industry of the United States Department of Agriculture and confirmed in all respects. The American results are published in a recent issue of the *Botanical Gazette* (Vol. LIII, No. 2, 1912).

Gram.

Some time ago a sample of gram was grown in the botanical area from which a number of pure lines were isolated in connection with the investigations on natural cross-fertilization published in No. IV, Vol. III of the Botanical Memoirs. Some of the more promising of these pure lines were grown in large plots in 1911-12 and the yields were carefully determined. Seven lines were grown and one plot contained local seed for comparison. The yields obtained were very high and the largest crop was nearly thirty-four maunds to the acre while two other lines gave over thirty maunds. Samples of the seed were submitted to Messrs Ralli Brothers, Bombay, for valuation and report. Four of the lines were valued over Rs. 4-8 per cwt. f. o. r. Bombay compared with Rs. 4-2, the price of the ordinary exportable varieties. The line which gave thirty-two and-a-half maunds of seed was valued at Rs. 5-8 per cwt. f. o. r. Bombay—an increase of Re. 1-6 per cwt. above the ordinary seed. These lines will be grown on a larger scale next

season and are also being tried in other parts of India. The results indicate that selection methods can be applied to gram with good prospects of success. As the flowers are self-fertilized in Bihar, it is likely that any improvement can readily be maintained.

Fibres.

The work with fibre plants has been continued, the crops studied being patwa (*Hibiscus cannabinus*), rozelle (*Hibiscus Sabdariffa*), and san (*Crotalaria juncea*).

It was found that one of the types of *H. cannabinus* grown from the seed of unprotected flowers could be freed from all hybrids in the seedling and early vegetative stages and thus could be kept pure by simple rogueing. It is possible that similar methods might be adopted in the case of cotton grown for seed distribution purposes. In the case of *san* progress was made in isolating the various varieties of this crop and a beginning was made in the study of the methods of pollination in this species.

In rozelle a considerable amount of work was done on the inheritance of characters in this crop and in the study of the second generation of the hybrids. The varieties of Indian rozelle are well adapted for the study by students of simple Mendelian phenomena and it was partly on this account that this work was undertaken.

Pollination.

Progress was made during the year in the study of the methods of pollination in the various crops of India and particular attention was devoted to some of the oil-seed crops. As soon as sufficient material has been collected these results will be incorporated in a paper.

Part IV.

The Tirhut Agricultural Exhibition.

The Tirhut Agricultural Exhibition was held in the botanical area at Pusa on January 18th, 19th and 20th,

1912, and I acted as local Secretary for the show. In addition to the usual exhibits of agricultural produce, live stock and the products of the local industries, the special feature of this Exhibition was the demonstration to planters, zemindars and cultivators. The nature of these demonstrations will be evident from the following extract from the report on the show :—

"An important departure was made this year in the Exhibition, largely through the efforts of Mr. F. F. Lyall, I.C.S., Collector of Mozafferpore. In 1910, it was suggested by the Imperial Economic Botanist that the Tirhut Exhibition should be held at Pusa once every four years and that the various improvements in Indian agriculture, shown to be possible by the work of the Pusa Institute, should be demonstrated to the planters, zemindars and cultivators of the Division in the form of growing crops of increased yield and value. This suggestion was not accepted for the 1911 show, but it was revived again by Mr. Lyall and adopted by Mr. H. C. Streatfeild, I.C.S., Commissioner of the Division. As a consequence, the Exhibition of 1912 was held at Pusa and the grounds of the Botanical Section were lent for the Exhibition. In the cultivated portion of this area, numerous plots were laid out to illustrate as many as possible of the improved methods of agriculture discovered at Pusa. The crops selected for this purpose were tobacco and wheat and, in addition, there was a further demonstration on two neighbouring plots of land belonging to ryots.

"The main demonstration to planters, which occupied about three hours, took place on the morning of the 19th January when the attendance was upwards of 50. This consisted of a series of short lectures by the Imperial Economic Botanist followed by discussions at the various plots. It was repeated in the afternoon for the benefit of those who arrived too late for the morning work. Leaflets dealing with the main subjects dealt with, were previously prepared and printed and sets of these were distributed. For the benefit of cultivators these demonstrations were given

in the vernacular, both on the 19th and 20th, by Moulvi Abdur Rahman Khan, Second Assistant to the Imperial Economic Botanist, and were largely attended. In addition to these formal demonstrations, the various members of the staff of the Botanical Section explained the work in progress to the cultivators and, in this way, a good deal of useful work was accomplished.

"The scope of the demonstrations can be gathered from the titles of the leaflets prepared for the show which were as follows :—

1. Green manuring with *san* for tobacco.
2. The improvement of wheat cultivation in Bihar.
3. The effect of grass on fruit trees.
4. The value of pure seed in India.
5. The importance of hot-weather cultivation in Bihar.

In addition, several improved implements, suitable for Bihar, were shown at work and various leaflets dealing with these machines were distributed. After seeing the spring-tine harrows at work fifty of these were ordered by the planters.

"These demonstrations were a great success and were followed closely both by the planters and by the cultivators. There is no doubt that this method of bringing home the results of the work of the Agricultural Department is infinitely more effective than publications or the exhibition of collections of seeds and other produce. An acre plot of improved wheat or tobacco for example appeals much more strongly to the agricultural mind than results in print or in the shape of collections of seed."

Part V.

The Development of the Fruit Industry of Baluchistan.

Progress has been made during the year in the work outlined in the last report in connection with the development of the fruit industry of Baluchistan,

A suitable site for the fruit experiment station was selected on the Sariab road about two miles from Quetta and the land was acquired in September 1911 by the Local Government. This was roughly laid out in terraces and plots last year, and, during the present summer, progress has been made in the final levelling of the plots and in making the necessary irrigation arrangements. Two shares in the Sirkhi karez have been purchased and two artesian bores have been laid down while a third is now in progress. These bores are 80, 150 and 250 feet in depth and tap three different water-bearing gravels. The total surface flow is expected to be well over 1,000 gallons per hour and the water will be finally collected in a pucca tank capable of holding four days' discharge. An experiment has also been made of pumping from one of these bores by means of an oil engine when the flow increased from 600 gallons to 4 25 gallons per hour. A well has been sunk which gave water at 22 feet and on this a Persian wheel is being erected. The water supply of the fruit experiment station is now assured and proposals have been submitted for laying down permanent masonry water channels for the main distribution and for carrying the zemindar's water through the area instead of in the present earth channels.

Five quarters for workmen, a cattle shed, two godowns, an implement shed and overseer's quarters were erected in 1911 as well as a building for laboratory and office work. The area has been surrounded by a wall and the road to the laboratory has been made pucca.

A portion of the land was laid out for a nursery and a number of stocks have been raised for budding during the present year. Some of the land was sown in *shaftal* for fodder and green manure.

The old fruit garden in Quetta was handed over on October 1st, 1911, and a beginning was made in getting this into order and in removing old trees. A portion of the area was got ready for *shaftal* and good crops were produced. Another portion was prepared for an experiment

in the growing of tomatoes on improved lines. During the present year, further progress was made on the work of renovation and it is hoped to get at least half of the land ready for a clover crop this autumn. Next year it is proposed to plant this area up in fruit trees.

A considerable amount of work was done in 1911 in working out the best methods of transporting fruit to India. It was found that the cheapest and best packages were those made up with chip and boards imported from Glasgow. Returnable boxes made of venesta wood were found to be impracticable under Indian conditions on account of the frequent overcharges and mistakes made by the Railway Companies in sending the empties back to Quetta. Any one sending returnable fruit boxes on Indian Railways on a large scale would have to keep at least one clerk to check the charges and to file claims. Another difficulty in connection with sending fruit by rail was the numerous thefts on the trains. If a merchant sending fruit from Quetta were to complain every time these thefts occurred, another extra clerk would be required for the correspondence that would be involved.

As a result of last year's experiments non-returnable boxes for the five-seer rate were designed and steps were taken to import a supply of material for these sufficient to meet the demands for 1912 and 1913. In addition, a supply of other boxes for experiments with tomatoes and other fruits was imported.

In carrying out the work at Quetta I have been greatly assisted by Mr. H. R. C. Dobbs, C.I.E., Officiating Revenue Commissioner in Baluchistan, who did a great deal to further the work after my departure in September 1911. Colonel McConaghey, C.I.E., the Political Agent at Quetta, has also rendered valuable assistance, while the work connected with the artesian bores and the pumping experiments was only possible through the ready help given by Colonel Williams, R.E., Secretary to Government in the Public Works Department, and by Colonel Picton,

A.C.R.E., Quetta. Colonel Duke, I.M.S., Residency Surgeon and Chief Medical Officer in Baluchistan, was kind enough to receive and plant out a number of young trees. He has also helped me by giving me the benefit of his local knowledge of fruit growing and of the practices in vogue in Persia.

My third assistant, Munshi Ijaz Husain, worked well at Quetta in the autumn of 1911 when left in charge of the work.

Part VI.

Programme and publications.

Programme of work for 1912-13.

1. *Training.*—The training of advanced students in this section will be continued.

2. *Plant Breeding and Plant Improvement.*—During 1912 the following crops will be studied :—wheat, tobacco, oil-seeds and fibre plants.

(*a*) *Wheat.*—The production of improved and rust-resistant types by selection and hybridization will be continued. The co-operative experiments on the influence of the environment on the milling and baking qualities of Indian wheats, which are being conducted in collaboration with Mr. H. Martin Leake, Economic Botanist to the Government of the United Provinces, will be continued. The botanical survey of the wheats of Baluchistan and the agricultural survey of the wheats of Bengal will be completed.

(*b*) *Tobacco.*—The production of new varieties by selection and hybridization will be continued, as well as the testing and curing of the varieties already isolated. The detailed study of the inheritance of characters in tobacco is being continued by the Personal Assistant.

(*c*) *Oil-seeds.*—The study of the oil-seeds of India will be continued on similar lines to those adopted in the investigations on wheat.

(*d*) *Fibres.*—The isolation and testing of pure races of the fibre plants of India will be continued. The study of the inheritance of characters in these crops is being continued.

(*e*) *Fruit.*—The fruit experiments at Pusa will be continued on the lines laid down in the first Fruit Report. During the months May to September the work connected with the development of the fruit industry of Baluchistan will be continued.

Publications.

The pressure of current duties has again delayed the publication of results and only a few papers could be written during the year. The work of the section, particularly on wheat and tobacco, has increased beyond all expectations during the past two years and it is difficult to find sufficient free time for writing papers and for correspondence.

The following papers were published or written during the year :—

1. Green manuring with *san*. *Agricultural Journal of India*, Vol. VII, Part I, 1912.
2. A suggested improvement in sugar-cane cultivation in the Indo-Gangetic plain. *Agricultural Journal of India*, Vol. VII, Part I, 1912.
3. The improvement of Indian wheat. *Journal of the Bombay Natural History Society*, October 1911.
4. A Hindi and Urdu version of Pusa Bulletin 22 on the production of wheat in India.
5. The Botanical aspect of the improvement of sugar-cane in India. *International Sugar Journal*, 1912.
6. The production and maintenance of pure seed of improved varieties of crops in India (with G. L. C. Howard). *Agricultural Journal of India*, Vol. VII, Part II, 1912.
7. Report on Economic Botany for 1910-11 for the Board of Scientific Advice (with R. S. Hole).

8. Some aspects of the Agricultural Development of Bihar—an address delivered to the Bihar Planters' Association at Mozaffarpore on January 31st, 1912.
9. The influence of environment on the milling and baking qualities of wheat in India, No. 2 (with H. Martin Leake and G. L. C. Howard). *In the press.*

REPORT OF THE IMPERIAL MYCOLOGIST.

(E. J. BUTLER, M.B., F.L.S.)

1. *Charge and Establishment.*—I remained in charge of the section until June 16th, when I proceeded on 20 days' privilege leave, Mr. F. J. F. Shaw officiating. In addition to my own duties, I also held charge of the post of Director of the Agricultural Research Institute, Pusa, until March 31st. Mr. Shaw held the post of Supernumerary Mycologist throughout the year. Mr. J. H. Mitter, Second Assistant, reverted from the Punjab Department of Agriculture on the abolition of the post of Assistant Professor of Mycology at Lyallpur, which he had held since May 1910, on November 24th. He has again joined the Punjab Department to officiate as Assistant Professor of Botany for three months from June 15th. All the staff have worked well.

2. *Training.*—Babu K. C. Banerji, B.A., L.Ag. (Nagpur), was sent for training in Mycology and Entomology by the Bihar and Orissa Department. He attended the section from February 22nd. Lala Bishambar Das, M.Sc., Assistant Professor of Biology, Government College, Lahore, worked in the Laboratory for about six weeks during his college vacation in July and August.

3. *Aid to Provincial Departments.*—A considerable number of parasitic fungi were named for the college collections in the various Provincial Departments, especially for Bombay, Bengal and the Punjab. The manuscript of the mycological portion of a Handbook of the diseases and pests of cultivated plants in Bengal was read through and annotated. Several blocks of original figures suitable for illustrating this book were lent to the Economic Botanist, Bihar and Orissa. Some manuscripts containing results of scientific work by the Assistant Professor of Mycology and the Mycological Assistant, Poona, were read and advice given as to the best means of publishing them.

4. *Plant disease investigations.* (*a*) *Paddy diseases.*—Considerable time has been given to the investigation of a disease of inundated paddy, locally known as *ufra*, in the deltaic districts of Eastern Bengal. The disease is said by the cultivators to have existed for at least a generation, but it appears to have greatly increased in virulence in recent years, and has been under the observation of the Eastern Bengal Department of Agriculture since 1908. It was attributed by different observers to insects, fungi and unsatisfactory soil conditions. A conjoint Entomological and Mycological investigation was undertaken last December, when Mr. Fletcher, Officiating Imperial Entomologist, and myself visited Noakhali District. The result was to exclude insects as the direct cause and to throw suspicion on a worm of the Nematode class, always found living on diseased plants. This worm, a *Tylenchus*, member of a genus whose species are already known to cause several serious diseases of cereals (of which " ear-cockle " in wheat is perhaps the most familiar), is exceedingly minute, practically invisible to the naked eye; it is found in clusters, often containing many individuals, on the surface of diseased parts. The anterior end is provided with a sharp spine and a sucking apparatus, by which the juice of the living cells of the plant is made use of as nourishment. At least two, probably more, complete life cycles occur in a year and, as the female lays a large number of eggs, increase is rapid. On diseased plants the worms are found, in the early stages, occupying small brown patches on the leaves and culm. As the crop approaches maturity larger numbers of worms occur on the peduncle of the ear and just above the next lower node. At these points the stem is deep brown in colour and shrunken to little more than the thickness of a thread. Still later, worms are found within the empty glumes of the lower flowers and the ears generally bear no grain. A frequent condition is the failure of the ear to emerge from its enclosing sheath and to this the name *thor* (or swollen) *ufra* is applied, from the swollen appearance of the head of the plant. In *pucca ufra* the ears

emerge, but are light and bear no grain. In Begumganj Thana of Noakhali District about half the crop was lost last year; several fields were visited which had not been considered worth harvesting. In 1910 it is estimated that the loss in this Thana was 200,000 maunds of grain. Outside Noakhali, the disease is said to occur in Comilla, Chandpur and the neighbourhood of Dacca and is probably more widely distributed than this. The same worm was found in specimens collected in these localities and the symptoms were similar. Elsewhere, from several of the rice-growing tracts of India, reports and specimens of diseases exhibiting points of resemblance to *ufra* have been received, but examination has not, so far, revealed the occurrence of true *ufra* outside Eastern Bengal. Further work is required to ascertain if the worm must be held directly responsible for the disease and, if so, how it can be checked. Experiments in this direction are in progress in collaboration with the Bengal Department.

An unsuccessful attempt was made to trace by field inoculations the life history of the " false " smut of rice caused by *Ustilaginoidea virens*. This is being repeated this year.

(*b*) *Root rot of plants due to Rhizoctonia.*—The soil-dwelling parasite *Rhizoctonia* has been known in Europe as a fungus pest since the early part of the eighteenth century. It attacks chiefly subterranean tubers such as potato, saffron, carrot and beet; in America it is also found on cotton. The researches of the past two years, carried out by Mr. Shaw and an account of which is now in the press, have shown that, in India, it is a parasite of wide range and, in some cases, extreme virulence. The species known as *Rhizoctonia Solani* Kühn, first described in 1858 on potato, appears to be most common. It occurs on potatoes at Bankipore, and on the Pusa Farm attacks jute, groundnut and cowpea. At Cawnpore it attacks seedling cotton and it has been reported on sesame from Surat. In some cases, *e.g.*, jute and cotton, the attack takes place in the seedling stage, when it is particularly virulent, in the case of jute the death rate in pot-culture being 70—80 per cent. The attack on cotton

was of interest as it proved to be identical with that known in Egypt as "sore shin" and in America as "damping off," both of which diseases were attributed by their investigators to an unnamed sterile fungus.

Special attention was paid to the possibility of the existence of biologic forms within the morphological species *R. Solani.* It was found that the race on jute was markedly different in its infective power from the fungus on cowpea, groundnut and cotton. The former would only infect its own host whereas the fungus upon either of the other three hosts could infect any one of the remainder.

A second species of *Rhizoctonia*, possessing much larger sclerotia, was found on groundnut and cowpea. It soon became clear that great confusion existed in the published literature between these two forms, which have been attributed to a single species under the name *Rhizoctonia violacea* Tul. The second form also occurs sometimes on potato, where it has been identified by American writers as *R. Solani* and stated to have a Basidiomycete, *Corticium vagum*, as its perfect stage. The investigations of the last year have confirmed the latter point but have shown that the fungus associated with *Corticium vagum* is a distinct and separate species. It is suggested that the name *R. violacea* may be retained for this form.

The fact that *Rhizoctonia* may live in the soil of an infected field for years renders the disease a peculiarly difficult one to combat. In Egypt a dressing of naphthalene has been found very beneficial in the case of cotton, while in England a weak solution of carbolic acid applied to the soil has given good results. The latter method is, however, too expensive for general use. It is fortunate that, so far, cereal crops appear to be immune to this disease and a careful rotation of crops is probably the best method of lessening its ravages.

(*c*) *Wheat rust.*—Last year was marked by a severe attack of wheat rust, the first for a number of years, in the Central Provinces. The disease was also prevalent in some

other wheat-growing areas, notably in Rajputana. Munshi Inayat Khan, senior Fieldman, was deputed to collect specimens and notes in the Central Provinces at the end of March. Examination at Pusa showed that, while all three varieties of rust were present, most of the damage was caused by " orange " rust (*Puccinia triticina*) and " black " rust (*Puccinia graminis*); " yellow " rust (*Puccinia glumarum*) was much less in evidence. Previous experience indicates that, in normal years, orange rust is absent or scarce in the Central Provinces, though common in Bengal and parts of the United Provinces. It appears, therefore, that in bad years this rust extends its area and much of the losses in 1912 must be attributed to it. In breeding rust-resistant wheats for the Central Provinces, yellow rust need not at present be taken into account. Black rust is always present and does much damage even in normal years; wheats resistant to this rust would be of undoubted value. As regards orange rust, the growth of wheats which withstand this variety would be a form of insurance against the occurrence of a rusty year. It is not, unfortunately, as yet definitely known whether wheats resistant to all three rusts can be produced. Meanwhile, as it is not possible in ordinary years to study the susceptibility of Central Provinces wheats in regard to orange rust, wheats which resist this rust in localities where it is prevalent might with advantage be introduced into the province.

(*d*) *Phytophthora investigations.*—Two species of this most destructive genus of fungus parasites have been under special study in the section. The first is *Phytophthora Colocasiæ* Rac., which attacks the common indigenous vegetable *kachu* (*Colocasia antiquorum*) throughout South-Eastern Asia. Its study was commenced by Mr. G. S. Kulkarni, Mycological Assistant of the Bombay Department, when a student at Pusa in 1909. It has since been continued by myself and its successful growth in artificial culture last year has allowed of the complete working out of its life history. It is hoped to publish the result of this work shortly. Mr. Dastur, First Assistant, has taken up the study

of a *Phytophthora* which attacks castor, as part of a larger investigation of the diseases of this crop. This species has also been got into artificial culture. The simultaneous production of the saprophytic habit by artificial culture in two species of this genus, until recently supposed to be exclusively parasitic, has permitted of important additions to our knowledge of the biology of the genus. *Phytophthora infestans*, the cause of the well-known potato blight, was found attacking potatoes and tomatoes at Jorhat in Assam; on a previous occasion, in 1902, it attacked potatoes in Burdwan and Hooghly Districts in Bengal. Ordinarily confined to temperate climates and always prevalent in the Hill Tracts of India, it is, perhaps, to be feared that a race is being developed which can withstand the heat of the plains.

(*e*) *Sugar-cane diseases.*—A memoir giving the results of the work of the past few years has been commenced. The difficulties encountered in carrying on field experiments, owing to inability to control external conditions which caused the partial loss of the crop on several occasions, have led to much loss of time. A good deal of information has, however, been obtained as regards methods of infection other than by planting diseased cuttings, both in red-rot and *Cephalosporium* disease, and it is considered advisable not to delay publication. This year's work includes these two diseases and also smut. Early in 1912 specimens of a cane disease which has appeared on the Jorhat Farm were received from Mr. Meggitt, Agricultural Chemist, Eastern Bengal and Assam, who laid stress on its resemblance to *sereh*, the disease which has caused more damage in Java than probably any other of the numerous diseases of this crop. The resemblance is indeed striking and a recent visit to Jorhat has not enabled me to identify the disease with any of those known in India. The symptoms of *sereh* are elusive, its cause is unknown, its treatment very troublesome; and the accurate identification of the Jorhat disease, so that measures for its suppression may be taken if necessary, is obviously a matter of the first importance.

(*f*) *Palm diseases.*—The " plague " of betelnut palms in Bengal and Assam has continued to spread to the north and east since first reported to Sir George Watt in 1896. Since 1905, when I visited Sylhet to attempt to discover its cause, it has extended to Cachar and Goalpara. Specimens from these districts, and from Khulna at the other extremity of the affected area, were examined during the year. The cause appears to be the fungus *Polyporus* (*Fomes*) *lucidus;* this species occurs commonly on dying palms and reasons were given in 1905 for supposing it to be parasitic. More recently it has been found on diseased areca and cocoanut palms in Mysore and Ceylon, and though its parasitism has not been conclusively proved, it is considered to cause disease in both localities. The losses in North-Eastern India have been enormous, but the area affected is so large as to render impracticable any attempt to check it on the lines of the successful work against bud-rot in Madras. The application of lime has been recommended and is reported to have had a beneficial effect.

(*g*) *Tea diseases.*—Mr. Shaw visited Cachar in December to investigate tea canker. The cause of this disease still, however, remains obscure. An *Exobasidium*, closely allied to that which causes " blister-blight " of tea, was discovered by Mr. I. H. Burkill in the Khasia Hills on *Camellia drupifera*, a wild relative of tea. I had some hope that this would serve to explain the spread of blister-blight from North-Eastern Assam to Darjeeling, but on submission to a specialist it was found to be a distinct species. Blister-blight was severe in parts of Assam this season and suggestions for further experiments to aid in its control were given to enquirers. The Scientific Department of the Indian Tea Association published an account of the suggested connection between the tea-seed bug (*Pœcilocoris latus*) and the fungus infection of tea seed, based on work carried out by me in the previous year. The section has been freely consulted by that Department during the year.

(*h*) *Indigo disease.*—A recrudescence occurred towards the end of last season of the so-called " wilt " of Java indigo

in Bihar, particularly where "moorhun" plant was kept for seed bearing. As there is much confusion between the condition due to the insect pest *Psylla* and that known as "wilt," a conjoined mycological and entomological investigation was undertaken. I visited the Research Station of the Bihar Planters' Association in November and examined the crop which had been kept for seed and which was at this date almost entirely destroyed. No sufficient explanation of the death of the plants could be found and it appears unlikely that it is due to a definite fungus parasite. As, on the other hand, it appears to be quite clear that Psylla does not kill the plant in this fashion, it is evident that further investigation is necessary. The preliminary stages of this were commenced last year.

(*i*) *Forest tree diseases.*—A large number of specimens of diseases of forest trees were received from the Forest Department. These included various pines, deodar, shisham, teak, "nahor," *Casuarina*, "sal," "mahua," *Cassia fistula*, mulberry, etc. In several cases the diseases were due to parasites already known and suggestions for treatment could be given. In others, notably the *nahor* disease in the Sibsagar and Teesta Divisions, the cause is a fungus which it has not yet been possible to identify and no recommendations can be made.

(*j*) *Other plant diseases.*—I visited Lyallpur in October to investigate the cause of the death of cotton plants in certain areas of the Government Farm. No parasite was found but evidence was obtained to show that the damage was due to root injury, resulting from the presence of an impermeable stratum some distance below the surface of the soil. A large number of specimens of cotton plants from fourteen villages in the wilt-infected area in Berar were sent for examination by Mr. Clouston. The percentage of wilt varied from over fifty to three. *Buri* cotton, so far, remains immune and Mr. Clouston is now working out how far this advantage compensates for its lower yield as compared with the varieties commonly grown. Mr. Shaw has investigated the disease of Sisal caused by *Colletotrichum*

Agaves and has prepared a note for publication. He also visited the Sisal plantation of Messrs. Allen Brothers near Cawnpore to report on its health. An outbreak of lucerne mildew was reported from the Remount Depôt, Sargodha, and of cauliflower mildew from Lahore. Experiments were continued with a view to finding some practical method of checking anthracnose of plantains. The stem rot of papaya was also under study, as its cause has not yet been determined. Mr. Shaw made a local investigation of the orange disease in the Khasia Hills, whence the " Sylhet " oranges of the Calcutta market are exported. The cause of this very obscure disease is still unknown. Oat smut was prevalent in Bihar and recommendations for its treatment have been made. A disease of coffee berries from Coorg was found to be caused by *Colletotrichum Coffeanum* Noack, a parasite which I had previously observed attacking the leaves of this plant, but which was not known to attack the berries. Mr. Shaw has commenced the study of *Striga*, a parasitic flowering plant which does much damage to sugar-cane, jowar and other Gramineæ in India. Amongst the diseases not previously known in India, cotton anthracnose, lucerne mildew and rust of velvet beans were the chief. Two diseases of wild vines were investigated, one of which is known to attack also the cultivated species. An account of them was published since neither occurs in Europe and, if introduced, they might prove serious pests in grape-growing countries. The usual routine work of dealing with enquiries and specimens sent in for report was continued. Altogether 98 parcels of specimens were examined.

5. *Systematic work.*—A considerable advance was made in this branch of the work of the section, the additions to the named herbarium collection numbering some hundreds. These were for the most part plant parasites, about 200 additions to the parasitic flora of India having been made. Two parts of the list of Indian fungi, which is being prepared in collaboration with Messrs. H. and P. Sydow of Berlin, were published. These contained the record, and in many cases also a detailed description, of over 300 species of

Indian fungi, of which more than a hundred were new to science. An account of an interesting aquatic fungus was also published. The total number of mounted sheets added to the herbarium was 779.

6. *Miscellaneous.*—I attended the meetings of a committee appointed to consider the question of preventing the importation of noxious insects and plant diseases into India, held at Pusa in November. It is greatly to be desired that action in this direction should be taken without delay. The measures recommended last year for checking the spread of lantana, a noxious weed in Mysore and Coorg, are under consideration and further information has been supplied to the authorities concerned. The section fitted up a stall at the Tirhut Agricultural and Industrial Exhibition held at Pusa in January, which was well attended. Assistance was given to the Government College, Lahore, in providing material and notes for teaching elementary mycology. An outbreak of dodder in clover was reported from Peshawar and recommendations for its suppression were made. I wrote the chapter on Mycology for the Annual Report of the Board of Scientific Advice for the year 1910-11.

7. Programme of work for 1912-13.

(*1*) *Research and experimental work.*—The investigation of the disease of paddy known as *ufra* in Bengal will be continued. Other diseases of paddy will be taken up as opportunity occurs.

Work on sugar-cane diseases will be continued. The disease which has appeared on the Jorhat Farm will be specially studied with a view to determining whether it is *sereh.*

It is proposed to examine the wilt diseases of cotton and sesame, in the Central Provinces, with a view to ascertaining their causes.

It is hoped to conclude the investigation of two species of *Phytophthora* and the diseases of castor and *Colocasia* caused by them.

The study of the so-called " wilt " of indigo will be continued.

The Supernumerary Mycologist is engaged in an investigation of some Phanerogamous plant parasites, especially *Striga*.

(*2*) *Training*.—This will be continued on the lines indicated in the Prospectus. Short courses will also be given if any students of the Institute wish to attend.

(*3*) Advice regarding the fungus diseases of plants will continue to be given to other departments, particularly the Provincial Departments of Agriculture and the Forest Department, and to the general public. The distribution of named specimens and other material to provincial colleges and other institutions will be continued.

(*4*) The collection and identification of Indian parasitic fungi will be continued.

8. Publications.

Fungi Indiæ Orientalis, Part III, H. & P. Sydow and E. J. Butler. Annales Mycologici, Vol. IX, No. 4, 1911; *ib.*, Part IV, Vol. X, No. 3, 1912.

On Allomyces, a new aquatic fungus, E. J. Butler. Annals of Botany, Vol. XXV, October 1911.

The rusts of wild vines in India, E. J. Butler. Annales Mycologici, Vol. X, No. 2, 1912.

A disease of Cotton, F. J. F. Shaw. Mufid-ul-Mazarain, September 1911 (*vernacular*).

Copper Blight of Tea, F. J. F. Shaw. Quarterly Journal of the Scientific Department, Indian Tea Association, Vol. I, Part 3, 1911 (reprint).

REPORT OF THE IMPERIAL ENTOMOLOGIST.

(A. J. GROVE, M.Sc.)

1. *Charge and Establishment.*—The Imperial Entomologist, Mr. H. Maxwell-Lefroy, was away on long leave during the whole of the period under review. Mr. T. Bainbrigge Fletcher held charge of the section until April 19th, when he proceeded to Coimbatore to take up his new appointment as Entomologist to the Government of Madras. I joined my appointment as Supernumerary Entomologist on October 27th, 1911, and, since Mr. Fletcher's transfer, have carried on the work of the section. The First Assistant, Mr. C. S. Misra, has been in charge of all the field-work on the Pusa Farm and the botanical area, and of the arranging and carrying out of the lac work including the giving of two short courses in Lac cultivation. He has also assisted in the instruction of students in General Entomology and field-work. In addition to this heavy routine work, he has continued his investigations on the *Aleyrodidæ* and other Hemiptera. The Second Assistant, Mr. C. C. Ghosh, was on privilege leave from May 6th to June 30th, 1912. He has been in charge of the Insectary and has continued to carry out extremely useful work on many insect pests. Mr. G. R. Dutt, Third Assistant, has had the Economic Collections, records, correspondence and the distribution of coloured plates and lantern slides in his charge. In August 1911, he was sent to the Punjab and remained there for nearly three months organising and directing the campaign against the Cotton Bollworm. In this and his other work he has done admirably. Mr. Nowrojee, who was away on privilege leave from December 15th, 1911, to January 14th, 1912, has been in charge of the general collections and has done good work in arranging and keeping them in order. Mr. M. N. De had charge of the Silk House and has shown much interest in the work.

2. *Visitors.*—Mr. A. E. Andrews, Entomologist to the Indian Tea Association, worked in the Laboratory during the latter part of December and the beginning of January and again in February. Dr. A. D. Imms, Forest Zoologist, visited the section for a short time in January. Dr. H. Morstatt, Entomologist at Amani, German East Africa, worked for a time in the Laboratory. Mr. Johann Lang of the Basel Mission, Calicut, came to Pusa to acquaint himself with the details of Eri Silk culture and spent a short time working in the Silk House. Mr. Akhtar Mohammad Khan, Deputy Collector in the United Provinces, on special duty for silk work, visited Pusa during March to consult with the Officiating Imperial Entomologist.

3. *Training.*—The Assistant Professor of Entomology at the Lyallpur Agricultural College continued his course of training, but was recalled to his Province before this was completed. The Entomological Assistant in the North-West Frontier Province, after completing his course, remained working in the Laboratory until October 14th, 1911, and again from December 1st, 1911, till February 22nd, 1912, preparing show-cases of insect pests found in his Province. An Entomological and Mycological Collector to the Department of Agriculture, Bengal, was trained in Economic Entomology from August 10th, 1911, to February 22nd, 1912. A private student deputed by the Department of Agriculture, Travancore, for a course in General Entomology, was admitted on June 1st, 1912. Seventeen students attended the short courses in Sericulture; seven completed their course and five are still being trained. The two courses in Lac cultivation were attended by thirteen students.

4. *Provincial Work.*—The importance of work in the Provinces is now fully realised as indicated by the appointment of an Entomologist to the Government of Madras. There are, however, only eighteen assistants working in the Provinces and two are still under training. Under these conditions the progress of the work of demonstrating to the

agricultural classes the principles of Economic Entomology must necessarily be slow. Pusa has continued to assist the Provinces, whenever requested, by checking and advising upon the work of the assistants and in many cases the technical work has been referred to Pusa, leaving the assistants free to carry out practical work in the field.

In Madras a vigorous campaign was carried on against the Deccan Grasshopper, *Colemania sphenarioides*, Bol. Bagging and ploughing of infested lands were carried out and a leaflet detailing the methods to be adopted against the hopper was issued. Light-trap experiments for the moths of the Hairy Caterpillars were also continued. Eri Silk culture was started and its suitability as a cottage industry for Southern India tested.

In the Central Provinces, the experiments against white-ants were continued in collaboration with the Deputy Director of Agriculture, Northern Circle, Hoshangabad. From past experiments with the mound-building form of termites, oiling the nest with low grade kerosine oil (as ordinarily procurable in the bazaars) was found most effective. Tests were also made with the " Universal Ant Exterminator." Arrangements were also made with the Director of Agriculture, Central Provinces, for the despatch of parasites of the Cotton Bollworms to Lyallpur, and for some time the Entomological Assistant was engaged in collecting and sending out the parasitized bollworms to Pusa and Lyallpur. Early in August information was received from the Director of Agriculture, Punjab, of a possible outbreak of the bollworms. Arrangements were therefore made for sending out the parasites from Surat and Nagpur to an assistant from Pusa to organise the work at Lyallpur. An acre under cotton and two acres under *bhindi* were also sown at Pusa to establish the bollworm parasites. By the end of October the parasite (*Rhogas lefroyi*) was well established in the Punjab and a leaflet was issued in the vernacular of the Province, explaining how the bollworm should be dealt with.

In the United Provinces, active measures have been adopted against the Rice Grasshopper, *Hieroglyphus furcifer*, a serious pest to sugar-cane.

In Bengal successful demonstrations were made against the Potato Moth (*Phthorimæa operculella* Zel.) and the advantages of storing seed-potatoes under sand were demonstrated to the Kaoris as well as to others engaged in the potato trade. A leaflet, explaining the methods to be adopted against the moth, was distributed at Tirhut and Bankipore Exhibitions. The campaign against *Agrotis ypsilon* was continued. The picking off of the first brood of caterpillars and the setting up of Andres-Maire traps reduced the loss during the past year to a minimum, so much so that out of a total area of 20,000 bighas, only 2,000 were affected. Eri work was begun and the Department completed a Crop-pests Handbook.

In Eastern Bengal and Assam, the *Ufra* disease of paddy, probably caused by an eel-worm, was investigated.

In Baroda, the campaign against the *Katra* (Hairy Caterpillar) was continued. Practical demonstrations were made and rewards were offered to cultivators for keeping the field embankments clean as a preventive against the pest.

In the North-West Frontier Province, on the resumption of duties by the Entomological Assistant, a survey of the crop-pests of the Province was started and effective measures were taken against the Peach and Tobacco Aphides.

5. *Correspondence.*—The work of replying to the numerous requests for information and advice on the many branches of entomological work continues to demand much time and attention, but in view of the importance of this part of the work of the section, no efforts have been spared to give applicants as full information as possible. Seventy-eight parcels of insects were received for identification and suggestion of methods of treatment and this was done as far as we were able in each case.

6. *Research.*—The investigation of the habits and biology of insect-pests has been continued and among those studied may be mentioned the "Bherwa," the Fish Insect, White Weevil, Mango Leaf Hopper, Surface Grasshopper, Parasites of Cotton Bollworms, Cane Borer, Cane Fly, Wheat Stem Borer, Termites, Grain and Flour Beetles. The experiments on the preservation of wood and other materials from the attacks of Termites (white-ants) are still in progress and the efficacy of various preparations and the relative immunity of different kinds of woods are being tested. At the request of the Bihar Planters' Association, an investigation into the "Psylla" disease of indigo was commenced and is being continued.

7. *Insecticides.*—A number of preparations sent in for trial were tested and reported on. The first edition of Bulletin No. 23 on insecticides speedily ran out of print and a second edition revised and with some additions has been published. As many inquiries have been received as to where various insecticides and spraying machines were obtainable lists of the firms supplying these have been prepared and circulated.

8. *Sericulture.*—The experiments with crossing multi- and univoltine races of Mulberry Silkworms to procure a superior silk-producing multivoltine race have been continued but though many crosses were made, it has up to the present been impossible to produce a stable multivoltine race, although as mentioned last year some improvement has been obtained in the quality of the silk.

Univoltine European races were successfully reared on pruned tree mulberry, wild mulberry and bush mulberry and arrangements have been made to distribute eggs of these univoltine races for rearing in October. The difficulty with these eggs is that the temperature of the plains is too high to preserve them successfully during the dormant period and arrangements have been made to send the eggs to places in the hills where the temperature is not so extreme.

The Eri Silkworms were reared successfully throughout the year except in May and June, when, owing to the

extreme heat and dry conditions, the worms did not thrive and disease broke out in the cocoon stage, necessitating the rejection of the majority of the eggs obtained.

Numerous requests have been received for disease-free Eri and Mulberry Silkworm eggs, samples of cocoons, thread and cloth, pamphlets, castor seed and mulberry cuttings and seeds, and these have been complied with whenever possible.

Exhibits were sent to the Bankipore Exhibition and to the Exposition held in connection with the Anniversary of the Calcutta Scientific and Industrial Association. A demonstration of Eri and Mulberry Silk rearing, reeling, spinning, weaving, etc., was given at the Tirhut Agricultural Exhibition held this year at Pusa.

One drawback to the progress of the Eri Silk industry is still the difficulty which small rearers have of getting rid of the cocoons when they have obtained them, as the mills will only take large quantities for spinning.

9. *Lac-culture.*—The work of collecting and sorting the specimens of lac insects, received from the various Forest Range Officers, was continued. Experiments in lac culture were again carried out and two short courses on Lac cultivation were given, thirteen students receiving instruction. Numerous enquiries were received and answered regarding the cultivation, and brood-lac was supplied to a number of applicants. Inoculated *Ber* and *Kusumb* plants were also sent to Japan. An exhibit, showing the details of lac-culture, was sent to the Tirhut Exhibition held at Pusa and copies of a leaflet on the subject written in the vernacular were distributed.

10. *Apiculture.*—Two more colonies of American Italian bees were obtained from England in November 1911 and have proved very successful from the honey-gathering point of view, but so far, all attempts to obtain fertilized queens for multiplying the colonies have failed, apparently largely owing to the activities of certain bee-eating birds. The experiments will be continued, as it is important to determine whether it is possible to multiply the colonies in this country. Experiments have also been made with the

common Indian bee, *Apis indica*, and attempts have been made to accustom it to the modern bar-frame hive. These in a measure have proved successful, but progress is slow, largely owing to suitable appliances not being available and more experiments are necessary before a definite opinion can be expressed. Several enquiries have been received with regard to apiculture and these have been answered as far as possible.

11. *Demonstration.*—The work of adding to the number of coloured plates of insect pests was continued and the new ones issued to the Provinces. A number of complete sets of coloured lantern slides were also issued. As mentioned previously, exhibits were sent to several Exhibitions.

12. *Insect Survey.*—Additions have been made to the general collections. Unnamed specimens of *Tettigidæ*, *Passalidæ*, *Cantharidæ*, *Rutelinæ* and *Psyllidæ* have been sent to specialists for identification and many of the collections sent out last year have been received back with the required information. Specimens have been identified for Provincial Assistants, the Indian Museum and many private collectors.

13. Programme of work for 1912-13.

As in previous years the work of investigating and advising upon insect pests will be continued. Assistance will be given, when desired, in co-ordinating the work of the Provincial Assistants and special help will be given in case of any serious outbreak. The preparation and issue of coloured plates and lantern slides will be proceeded with as before. The short courses in Lac cultivation and Eri and Mulberry silk-culture will be continued. Further experiments will be made with European and Indian bees. It is hoped that the collections of lac insects will be completed during the period. Eri silkworms will be reared and requests for help and advice will be complied with as far as practicable. The experimental work with Mulberry silkworms will be continued. New insecticides and apparatus sent in for trial will be tested and reported

upon. The field experiments with wheat and sugar-cane will be continued and further experiments have been commenced and will be carried on with a view to test the relative immunity of different varieties of cotton to the bollworm and also to extend the observations on the bollworm parasite.

14. PUBLICATONS.

The following is a list of publications which have appeared during the period under review. As material accumulates, other Memoirs on the life-histories of insects will be prepared. Several Memoirs are now in preparation and include life-histories of *Orthoptera, Hemiptera, Lepidoptera* and *Coleoptera.* The revision of *Insects injurious to Indian Agriculture* is being proceeded with.

LIST OF PUBLICATIONS.

The Food of Birds in India. C. W. Mason, edited by H. Maxwell-Lefroy. January, 1912.

Eri Silk. H. Maxwell-Lefroy and C. C. Ghosh. May, 1912.

Life-histories of Indian Insects II. Some Aquatic Rhynchota and Coleoptera. D. Nowrojee. April, 1912.

Life-histories of Indian Insects III. The Rhinoceros Beetle (*Oryctes rhinoceros*) and the Red or Palm Weevil (*Rhynchophorus ferrugineus*). C. C. Ghosh. December, 1911.

Second Edition of Bulletin No. 23 on Insecticides, by H. Maxwell-Lefroy, revised with many additions, by T. Bainbrigge Fletcher. May, 1912.

Grasserie in Silk-worms. M. N. De. Agri. Journal, July, 1911.

Weevil and Dry Wheat. T. Bainbrigge Fletcher. (Agri. Journal, October, 1911.)

A Simple Honey-extractor. T. Bainbrigge Fletcher. (Agri. Journal, October, 1911.)

The Wax Moth. T. Bainbrigge Fletcher. (Agri. Journal, October, 1911.)

The Cabbage White Butterfly. T. Bainbrigge Fletcher. (Agri. Journal, January, 1912.)

Article on Litchi Mite. C. S. Misra. (Agri. Journal, July, 1912.)

Leaflet on the Bollworm in Cotton (*Gurumukhi*). October, 1911.

Cotton Bollworms in the United Provinces (Vernacular). C. S. Misra. January, 1912.

The following are in the Press:—

Memoir on Tetriginæ. Dr. J. L. Hancock.

Memoir on Life-histories of Hymenoptera. G. R. Dutt.

Memoir on the Big Brown Cricket. C. C. Ghosh.

Bulletin No. 28 on the Cultivation of Lac in the Plains of India. C. S. Misra.

Bulletin No. 29 on Eri Silk.

REPORT OF THE IMPERIAL PATHOLOGICAL ENTOMOLOGIST.

(F. M. HOWLETT, B.A., F.E.S.)

The programme for the past year has been considerably modified in consequence of the much closer relation with medical work which now exists. I am indebted to the Administrators of the Medical Research Fund for the addition of three posts to my staff, of which two have already been filled. These extra men will be engaged exclusively with "medical" entomology, and there will thus be at least two men available for Veterinary, Agricultural, and general work. The provision of these posts has rendered the question of accommodation more acute than ever, and a portion of the extra space required has been provided by the erection of a small supplementary laboratory now completed.

I have already put forward certain suggestions for the establishment of a medico-entomological laboratory for Northern India where entomologists and medical officers could work at any group of blood-sucking insects under the best conditions for obtaining material and observing the living insects in their natural habitat without undue risk to health. Such a laboratory should be in a district where blood-sucking insects attain their maximum abundance and variety: examples of such tracts are the lower slopes of the Himalayas and the Western Ghats and certain parts of Assam. It should be in some place having a climate sufficiently cool to allow of operations such as section-cutting to be carried on without inconvenience at any season, but should be on a railway or good road affording easy access to tracts where insects abound. The establishment of such a laboratory at some place fulfilling these conditions (*e.g.*, Shillong, the Kurseong neighbourhood, the Naini Tal road from Kathgodam, Igatpuri) would not necessarily entail any large expenditure if a site were available, and would

enable observations to be carried on with a facility unobtainable at any existing laboratory known to me, with the possible exception of Coonoor and Madras.

The work of the section has been largely concerned with mosquitos, and the life-histories of eighteen species of Pusa mosquitos have now been worked out. Special attention has been paid to the genus *Stegomyia* and allied forms, and a five weeks' course of instruction has been given to medical officers deputed to the "Stegomyia-survey" in connexion with the possible future importation of yellow fever. Seven officers attended the course. The most interesting point discovered regarding *Stegomyia* life-histories is that during cold and dry weather the two commoner species at Pusa (*S. scutellaris* and *S. thomsoni*) survive normally as dry eggs and not as active, hibernating, or æstivating adults. This has an important bearing on the practical question of checking the increase of *Stegomyia*.

Investigations have been begun on general mosquito bionomics, the main heads being the influence of temperature on mosquitos; methods of colouring or otherwise marking mosquitos in order to study their movements, and the range and rate of flight under natural conditions; sexual reactions of mosquitos; new larvicides; the food, feeding, and digestion of mosquito-larvæ; fish and other enemies of mosquito-larvæ. The difficult question of the breeding-places and habits of *Phlebotomus* has been taken up. A possible association with Termites may prove of importance.

Simulium-infested streams at Simla were examined with a view to finding methods of decreasing the numbers of the fly, but local conditions are such that no cheap method seems applicable. The life-history of the Crab-louse (*P. inguinalis*) was worked out (apparently for the first time), and its curious habits studied.

Other subjects which received attention are the parasites of *Tabanus albimedius* and of *Monophlebus stebbingi* var. *octocaudata*, the nature of the attraction of citronella oil for fruit flies of the genus *Dasyneura*, the life-history of *Celyphidæ* and improvements in mosquito-traps. The

East Indian Railway school at Jharipani was subjected to hydrocyanic acid fumigation on account of a plague of bugs, and the result appears to have been satisfactory.

As Secretary of the Entomological Sub-Committee appointed by the Malaria Conference in Bombay, I assisted in drawing up a scheme for organising work in pathological entomology.

A hand-book dealing with methods of drawing and reproducing illustrations for scientific papers has been passed for publication.

Programme of work for 1912-13.

The programme for the ensuing year will be subject to modification in accordance with any special requirements on the medical and veterinary side: Directors of Agriculture are being circularized in order that we may ascertain whether with respect to the latter there are any particular directions in which investigation is required. The special lines of work suggested by the Medical Department are mosquito bionomics and the breeding-habits of sandflies: both of these will be continued, and will in all probability form the major part of "medical" investigations; the former subject alone is one to which several years of work might be devoted. It is suggested that an appeal should be circulated throughout the country to enlist helpers and stimulate interest in medical entomology, and that specimens and information received should be dealt with either at Pusa or Kasauli; details of the arrangements are still under consideration, but at least some part of the work in this connexion would be done at Pusa.

Identification of specimens and any other work that may be required in connexion with the "Stegomyia-survey" will be undertaken, and more detailed observations of these mosquitos will be carried on. Experiments on methods of checking their increase have been begun at Pusa, and will continue until the onset of the cold weather.

An attempt will be made to elucidate the nature of the influence of citronella oil on fruit-flies: some unexpected

results were obtained in the course of the past summer, and a clearer understanding of the matter is desirable in view of the wide distribution of these flies and the serious damage they inflict in various countries.

REPORT OF THE IMPERIAL AGRICULTURAL BACTERIOLOGIST.

(C. M. HUTCHINSON, B.A.)

I held charge of the section throughout the year.

1. *Charge and Establishment.*—The First Assistant Mr. N. V. Joshi was on privilege leave from October 9th to 23rd December 1911 and the Second Assistant Mr. K. S. Viswanatham was on privilege leave from April 9th to 29th June 1912.

All the Assistants in the section showed great interest in the work, and not only worked daily several hours overtime but made themselves sufficiently familiar with French and German to be able to read and make translations into English from papers published in these languages.

2. *Tours.—To Rangpur* to observe the conditions of incidence of bacterial disease of tobacco.

To Jorhat to see the manurial experiments carried out by Mr. Meggitt and the new Experiment Station of the Indian Tea Association.

To Dacca to consult Mr. Finlow on the subject of bacterial action in jute retting and "heart damage."

To Lyallpur to consult Mr. Barnes on the subject of "Reh" soils and to deliver a course of lectures on soil bacteriology.

3. *Soil Bacteriology.*—The work of the Bacteriological Section at Pusa during the year has been mainly directed towards ascertaining what factors determine biologic activity in Indian soils, and to the measurement of the changes resulting therefrom under various conditions. The main problem so far dealt with has been the supply of available nitrogen as provided by the biolysis of such substances as green manures, root residues, and organic manures. No work has been done upon nitrogen assimilation by Legume bacteria or such organisms as Azotobacter, Clostridium, or Rhizobium.

The method of determining the biologic activity of a soil by plate counts has been abandoned in favour of methods depending upon measurement of the physiological activity of the soil organisms. By the use of such methods biological analyses of soils may be carried out which will provide indications as to their relative capabilities for dealing successfully with organic manures. Far more valuable information, however, is also obtained by such analyses. By the use of fairly large portions of soil it is perfectly feasible to set up and maintain conditions of moisture and aëration comparable with those in the field, and to determine in the laboratory for any particular soil under what conditions of water supply, tillage, and addition of lime or manures, either natural or artificial, the greatest amount of ammonification and nitrification will result.

It has been ascertained by numerous experiments that the rate of formation of carbon dioxide in a soil is directly proportional to the biologic activity of that soil, and that conditions unfavourable to the latter will also adversely influence the former. A simple method of measuring the rate of formation of carbon dioxide in soils under various conditions has been devised and by this means it is possible to determine what moisture content of any particular soil is the optimum for bacterial activity; this has been found to vary from as high as 37 per cent. in one case to as low as 16 per cent. in another. By the same method the effect of the addition of various manures, organic or mineral, may be observed, and it has been found possible in this way to prescribe the addition of certain substances, such as lime or superphosphate, to a soil in order to promote the decomposition of green manures, oil-cake, or cattle manure buried in it. Similarly by determining the optimum moisture content, recommendations can be made as to variations in field practice which would tend to dry out the soil in one case or to conserve moisture in another; a very large number of observations have been made as to the conditions under which ammonification and nitrification take place in

Indian soils. It has been found that important differences exist between the biological changes taking place in the latter and those which have been observed in the soils of Europe; these differences appear to be due to the high average temperatures of Indian soils and their consequently high relative rate of bacterial action. In soil at temperatures between 15° C. and 18° C. the process of ammonification, which is the natural and necessary predecessor of nitrification, takes place at such a rate as to allow the latter to proceed *pari passu;* in many Indian soils, however, it has been found that at the higher temperatures 25° C. to 30° C. which obtain in them for many months in the year, ammonification may proceed with such rapidity as to produce a concentration of ammonia in the soil water sufficiently high to interfere with nitrification or even to inhibit it altogether. Where large quantities of nitrogenous organic matter are turned into the soil and put under intensive cultivation much nitrogen may be lost in the form of ammonia, and experiments have shown that the biolysis of organic nitrogenous material requires very careful investigation from this point of view.

It is evident that these facts must be taken into account in selecting the time of year for applying organic manures, along with other considerations depending on local meteorological conditions and the optimum moisture content of the soil.

Further experiments have demonstrated another source of loss of nitrate nitrogen. It has been shewn that where intense bacterial action is taking place in soil any nitrates present will be reduced without the occurrence of anærobic conditions; it appears probable that the nitrate is utilized as a source of nitrogen by the bacteria. It was found, for instance, that in Pusa soil the optimum moisture content for nitrification is 16 per cent. whereas general bacterial action is intense up to 25 per cent. and at the latter figure rapid reversion of nitrate to the protein form takes place. This would help to explain observations made in field practice both at Pusa and in the Punjab, that excess of soil

moisture produces nitrogen starvation of the wheat crop; the importance of biological analysis of irrigated soils by such methods will readily be realized.

A special enquiry has been carried on and is still proceeding, to determine the conditions under which bacteriotoxins are formed in soils and their effect in inhibiting bacterial action. The work of Greig Smith of N. S. Wales on this subject has demonstrated its importance, and experiments at Pusa have fully confirmed his views. Mr. Meggitt, Agricultural Chemist, Eastern Bengal and Assam, with whom I hope to collaborate on this subject, has carried out a series of investigations on similar lines, but the enquiry is not sufficiently complete for detailed report.

A complete series of experiments on green manuring was designed and commenced, in collaboration with the Imperial Agriculturist. This included observations in the field and in the laboratory as to the effect of varying treatment of the green crop (*Crotalaria juncea*) upon the condition of the soil and upon the succeeding crop. Field variations included burying after varying periods of growth, at different depths, and in conjunction with various artificial manures. Laboratory experiments were carried out to determine the rate and kind of change of the buried organic material under various conditions, with special reference to the formation of nitrate, and in order to obtain data which might help to elucidate the problems connected with the occasional failure of green manuring to improve soil conditions.

This enquiry will continue over two more seasons.

4. *Plant Pathology.*—A bacterial disease of tobacco at Rangpur was investigated and found to be due to an infection of *B. Solanacearum.* The strain isolated was found to be also pathogenic to *Solanum Melongena,* Tomato, Datura and Potato. The incidence of the disease at Rangpur and Burirhat was not apparently associated with any insect attack or specially unfavourable soil conditions, and was not heavy enough to cause apprehension as to future spread. The parasitism of the causative organism as

isolated from diseased plants in the field was found to be insufficiently strong to attack healthy plants, although by passage through several individuals or by artificial culture on Potato it could be raised to a high degree of virulence. For this reason the practice of leaving the plants in the ground for a second cutting should be avoided in infected areas.

A bacterial disease of wheat in the Punjab, locally known as "Tannan" or "Tandu," was investigated; this was found to be due to the attack of a bacillus closely resembling *Ps. Hyacinthi* which invests the opening ear with a sticky growth causing deformation and stunting and preventing ripening of the grain. The attack is confined to small badly drained areas and can probably be avoided by proper cultivation; its distribution is limited and it is probably of no economic importance.

5. Programme of work for 1912-13.

Work on influence of soil conditions upon nitrification will be continued.

A new line of enquiry will be commenced this year with the object of determining the conditions under which nitrogen fixation by so-called non-symbiotic organisms may balance losses of nitrogen due to various causes under agricultural conditions.

The green manuring experiments will be continued in collaboration with the Imperial Agriculturist.

Should time permit an attempt will be made to obtain more precise data as to the effect of variations in temperature, moisture, and aëration upon nitrification in soils with special reference to field conditions and agricultural practice. The apparent inhibitory action of various crops will be taken into account, and the effect of different systems of cultivation upon aëration and moisture content of soil.

Work on formation of soil toxins and their influence upon bacterial action will be continued. It is hoped that this may be done in collaboration with Mr. Meggitt.

Experimental work on the "Ufra" disease of Paddy with reference to soil conditions will be continued.

Indigo wilt.—This will be investigated with a view to the possibility of its bacterial origin.

Training of students will be continued.

6. List of Publications.

Hutchinson, C. M.—Studies in Bacteriological Analysis of Indian Soils—No. 1, 1910-11 (Mem. Dept. of Agriculture in India, Bacteriological Series, Vol. I, No. 1).

ANNUAL REPORT OF THE IMPERIAL COTTON SPECIALIST.

(G. A. GAMMIE, F.L.S.)

I held charge of the appointment throughout the year. The first two months were devoted to the establishment of the series of experiments on which I had decided to work out the manurial requirements of the cotton plant in India and the differences which may perhaps accrue from the presence of various manurial ingredients in the soil. This enquiry will only give data for estimating results in the course of a few years.

In September and the early part of October I visited the Mysore State to suggest some preliminary lines of experiments. The greater part of October was devoted to a tour in the Punjab and the United Provinces.

In November I visited Berar and then attended the Conference of the Agricultural Board at Pusa where I had opportunities of discussing cotton work with members of all the Agricultural Departments in India.

In January I visited Assam to advise a planting firm regarding the cultivation of cotton in that Province.

During the intervals throughout the year I was engaged in supervising my own experiments and in advising, with some degree of detail, more than twelve correspondents in India and other parts of the East, on special points connected with the cultivation of cotton.

To further my botanical researches I obtained seeds of the indigenous cottons in the Kashmir State and the varieties of wild cottons existing in Sind.

A number of cotton samples were exhibited and explained at the Mysore Industrial Exhibition. For these the committee awarded a diploma and the notes accompanying the exhibits were considered sufficiently useful to be quoted in full in the Exhibition catalogue. A set of cottons were sent for exhibition in the North-West Frontier

Province, by Mr. Robertson Brown, who considered that the quality of the samples would help the cultivators to realise how cotton should be turned out for the market.

To simplify this Report for purposes of reference I give the information I have gathered from each Province separately.

The Central Provinces and Berar.—Mr. Low, the Director of Agriculture, at the general meeting of Agricultural Associations at Akola, in November, ably summarised the present condition of cotton cultivation in his Province and, as this paper was presumably only for the information of members and visitors and will probably never attain general circulation, I take the liberty of transcribing such portions as pertain to my subject. Having been honoured by being allowed to follow closely the work done in the Province, since its initiation, I can vouch for the accuracy of the details, and the importance of the subject requires no apology for its introduction.

The centre of cotton work is at the Akola Experimental Station, which was opened six years ago. Great care was taken to select uniform areas for the different series of experiments. This was done by growing *juar* over the whole area to start with and by selecting areas of uniform fertility as ascertained by experimental weighings. Where the land was found to be uneven in fertility, as proved by variations in the outturns, it was discarded as being unsuited for experimental purposes.

From the experiments, which have now been going on for five years, several very practical lessons have already been learnt. These are being carried into practice in the non-experimental areas and are also being recommended for adoption by other cotton growers. It has been proved that the turn wrest plough is an excellent implement for eradicating weeds and for deep and thorough cultivation generally; that the Hoshangabad iron tined *bakhar* is a very useful implement for uprooting cotton stalks in the field before preparing the land for the next year's crop; that the Akola hoe is a better implement than the Berar *doura* for

interculture as it produces a deeper tilth in the black cotton soil. Turn wrest ploughs will, in future, be made in India by Messrs. Burn & Co., Calcutta, and agents have arranged to stock them at the various cotton centres.

Much attention is being paid to experiments with the different manures on this farm and the excellent crops that clothe the fields are largely the result of high manuring.

Most cultivators in this Division grudge to pay even 12 annas for a cart-load of cattle dung; its manurial value for cotton is at least twice that. The cultivator who neglects to manure his land is a loser because by withholding one small item of expenditure, namely, manure, he lessens very considerably the effectiveness of the other items, *viz.*, cost of cultivation, seed and supervision. Increased outturns have been obtained on the farm from the use of cattle dung, poudrette and saltpetre as manures for cotton and *juar*. The most economical of these is poudrette which is obtainable in fairly large quantities from all the large towns in Berar. A source of manure which is neglected all over India at present is cattle urine when conserved by the dry earth system. It has been proved at Akola that, for cotton and *juar*, the manurial value of a farm animal's urine is equal to that of its dung and by conserving the liquid manure, the value of the manure available on a farm can be doubled.

Nitrogenous fertilizers, such as nitrate of soda and saltpetre, when used as a top-dressing after the application of cattle dung, have also given very good results. It will pay to use them as a manure for cotton to supplement the inadequate supply of cattle dung so long as the price of that staple remains high.

The quantity of lint yielded by each variety varies from $36\frac{3}{4}$ seers per acre for *bani* to $80\frac{1}{2}$ seers for *rosea*. As the value of a cotton depends very largely on the quantity of lint which it gives, *rosea* stands easily first and *bani* is distinctly the poorest yielder. The advantage to be gained by growing *rosea* in preference to Berar *jari* is that it gives

more *kapas* and a higher percentage of lint. A profit of about Rs. 11½ per acre is made on this farm by growing *rosea* instead of Berar *jari*. *Malvensis* also does well in certain localities and the lint is much superior to that of *rosea*, but it is a less profitable variety to grow owing to the lower percentage of lint which it yields.

Vera closely resembles *malvensis* and *cutchica* somewhat resembles *rosea*.

Bani or *Hinganghat kapas* is, from the point of view of quality, one of the best cottons grown in India, but it gives less than half as much lint as *rosea* and buyers are not willing to pay more than from 20 to 30 per cent. more for its lint than for that of *rosea*. Consequently it is hopeless to expect that it can be grown as profitably as *rosea*. The only chance of improving it with effect seems to be to raise the ginning percentage. The strain, evolved by selection on the farm gives 3 per cent. more lint than ordinary *bani*.

Bhuri is the best exotic cotton yet tried in the Province. It is entirely resistant to wilt which is now doing considerable damage to Berar *jari* in certain parts of the Division. *Bhuri* is recommended for such areas and for the rich *khari* lands of the villages. It suffers more from drought than Berar *jari* but less from excessive rain. Before this farm was opened the terms *rosea*, *malvensis*, *cutchica*, etc., were quite unknown, but now these are household words in Berar and many cultivators are growing these varieties pure for seed distribution.

Rosea is being grown on 31 seed farms in this Division; *malvensis* and *cutchica* on 4, *bhuri* on 33, and it is reckoned that there are 5,000 acres under this new variety in Berar alone this season. It is gratifying to note that all this has been accomplished by the Department of Agriculture, mainly through the agency of the Akola Farm, within the short space of five years, and that these different varieties had never been grown pure previous to that time. Several cultural points have also been decided, such as that topping

cotton reduces the yield, that the best spacing distance for Berar *jari* is 15 inches apart for the rows and 7 inches apart for the plants in the rows, that cotton sown before the monsoon breaks gets a good start and gives a larger yield than that sown after the rains have set in, if the blanks are dibbled in.

Mr. Clouston adds that cotton grown continuously in the same field for a period of years has become a fairly common practice in Berar. This disregard of the principle of rotation in cropping is decried by scientists, who attribute to it the spread of insect pests and fungoid diseases. The results, up to date, however, have not justified that assumption. The experiment has now gone on for four years; no trace of disease and no serious damage by insects have yet been noticed. Economically the practice has proved a sound one owing to the high price of cotton and it is, therefore, being followed in the non-experimental area of the farm.

Finally, the increasing demand for pure *rosea* seed has been very marked. The Department admit that, in this part of India, *bhuri* cannot be grown at as large a profit as *rosea*, except in wilt-infested, wet or *khari* areas. Cambodia cotton gives a poor return. It is more than a month later than the indigenous varieties and suffers from the early cessation of the rains in Berar.

In my last year's report I explained the good work that is being done at the Khandwa Agricultural Station by Mr. G. Evans, the Deputy Director of Agriculture, Northern Division, Central Provinces. This year he has furnished samples of five sorts of cottons grown at the same station and of two samples which he has picked out during his researches throughout his District. One is from Chhapara, a high plateau in the Seoni District of the Satpura, and the other from Patan in a part of the Jubbulpore District which is liable to early frost. He considers from the geographical situation of both tracts that an early ripening variety is absolutely essential. From the valuations it

is evident that these tracts already possess a fairly valuable cotton.

Messrs. Tata, Sons & Co. have kindly furnished me with the following valuations and remarks on all the above-mentioned seven samples :—

Valuation furnished by Messrs. Tata, Sons & Co., Bombay, on the seven samples of cotton from Khandwa, on 20th February 1912.

Serial No.	Name of sample.	Remarks.
1	*Bhuri*	Compared with local cotton of Khandwa this cotton is far and away superior. It is soft and silky in feel and has a fine long fibre. It is more like the Bassim cotton of the tableland. Taking Akola as our basis for valuation at Rs. 275 we value this cotton 15 rupees higher, say Rs. 290.
2	*Malvensis* . . .	Same style of cotton as No. 1, but the length of the fibre is slightly shorter though the staple shows more strength. Same value as above, *viz.*, Rs. 290 per candy.
3	*Cotton from Chhapara* .	Bengal style of cotton, but of superior quality for which we value it 10 rupees higher than Fine Bengal, *viz.*, Rs. 280 per candy (Bengal Fine Rs. 270).
4	*Saugor jari*	Same style as No. 6, but a shade better and more even in staple. Value Rs. 275.
5	*Local*	Same as No. 4. Value Rs. 275.
6	*Roseum* . . .	This cotton is equal to local Khandwa cotton and shows no improvement. Value same as for local Khandwa cotton, *i.e.*, Rs. 270 per candy.
7	*Patan*	Punjab style of cotton. Compared with No. 3 it is inferior in colour but a shade better in staple. It is more like fine Mooltan cotton. Value Rs. 265.

Punjab.—I visited the Punjab in October and completed a joint inspection of the cottons of that Province, with Mr. Milne, the Economic Botanist.

There are two varieties of the dark flowered and broad lobed *G. sanguineum*, one with dark, the other with green

stems. Great variations in staple are found in these plants. Selection experiments have proceeded probably as far as they can be taken and the staple obtained attains the length of ·8 inch. It has been proved that the shortest staple is associated with the hardiest and darkest coloured plants. Excepting the characteristic of coloration which is a negligible factor in other parts of India, the above fact is a further confirmation of our experience that hardiness and poor staple are companion characters.

The variety which I have already published under the name of *G. obtusifolium* var. *hirsutior* seemed to be unsuited for cultivation owing to its prolonged season of growth, but it may yet prove useful in cross-breeding.

The remaining indigenous forms of Punjab cottons are yellow and white flowered forms of *neglectum* and *indicum*, all, however, with a strong tendency to show true *neglectum* characters.

Khaki hirsutum is unsatisfactory from its producing cotton of varying tints and many bolls bear quite white cotton. A good, even, white colour is a desideratum in a cotton produced for sale in the Indian market and buyers are prejudiced against coloured cottons.

Of the indigenous types the broad lobed *sanguineums* are by far the most promising and it would be well to draw the attention of the cultivators to these as they are of a particularly desirable type. The outturns of all the plots appear to be excellent.

The Upland cottons were described to me by an American expert as being the best he had seen outside the United States.

Two varieties come into bearing as early as the indigenous cottons, but it is still to be seen whether they are quite early enough to save one watering or not and this is a matter of important consideration to the zemindar. The successful introduction of these cottons into more general

cultivation will, of course, depend on the willingness of the selected zemindars to devote more careful attention to cultural methods than they at present exercise in the case of their *deshi* cottons. The valuations received on these cottons show, by a comparison of outturns, that the most highly priced varieties are by no means the most profitable to grow.

Mr. Conville, a local cotton merchant, mentioned that during this year he had observed a great improvement in the cultivation of cotton in the Colony and he attributed this advance to the good example held out by the Lyallpur Farm. He considers that the bad practices of cotton sellers and buyers, ginneries, etc., have helped to lower the prestige of Indian cottons.

Mr. Miliades says that in his long experience of Lyallpur, the yield of cotton has fallen from 10 to 12 maunds to 4 or 5 maunds per acre. He thinks that this decrease is wholly caused by the diminishing fertility of the soil which was practically virgin land only a few years ago. Mr. Milne explained to me that the natural indigenous vegetation of the tract before the days of irrigation consisted mainly of leguminous plants and that the cotton yielded its maximum while the plants could draw on the nitrogen stored in the soil. His idea of introducing Berseem or Egyptian clover as a fodder and a renovator of the soil is a sound one and I shall follow with interest the results of his experiments. The deterioration of some well-known staples in the Punjab is said to be due to careless cultivation and treatment. Multan cotton (a pure *sanguineum*) is a hardy cotton capable of producing full crops on the western side of the Province. Mr. Miliades considers that even now, in many respects, he prefers this cotton to the *Narma* or acclimatized Upland cotton.

Mr. Roberts is growing on a field scale what has been handed over to him by the Economic Botanist and he already has urgent demands for select seed from the cultivators. This is, in itself, sound proof that the cultivators realize the value of what is being done for them. The

maintenance of pure types in their hands, however, is the most difficult problem confronting the Department and it is impossible to foresee at present how it can be solved. A due appreciation of the difficulties of this task leads us to the conclusion that, although a number of varieties can be safely tried on a small scale, for distribution purposes it would repay the Department to work with one *deshi* and one American only. Afterwards when it is known that special tracts require their own special varieties, then the safest course to pursue would be to establish seed farms on these areas. This has been already successfully accomplished in the Central Provinces.

Messrs. Tata & Sons of Bombay have courteously given me a report on Punjab cottons drawn up by one of their agents who was buying Upland cottons. The following is the gist of it: "The *deshi* and American cotton grown in the Lyallpur District have been deteriorated by boll weevil and frost and in some parts large tracts of cotton fields have been totally destroyed. The total crop in this district would be about 10,000 to 11,000 bales, whereas last year it was about 35,000 bales. The general complaints about the *kapas* this year are large percentage of unripe *kapas*, yellow stains from boll weevil and short staple. These tend to give decreased outturn and dull colour. The cultivation of American cotton is not yet universally taken up in the whole district. It is chiefly grown on the horse-breeding farms, called Risala, the Agricultural Farm and by a few private farmers. The crop of Risala No. 15 is the best in the district this season. The seed was obtained from the Agricultural Farm, which obtained it from Dharwar some years ago. On the whole the quality of this cotton is good except that no care seems to have been taken in picking. The fibres are strong and pliable and the regularity in their length would enable good yarn up to 24^s to 40^s to be made in warp and weft. I am sorry I am not able to make the same remarks on other American cottons grown in the district.

" I have seen several samples of American cotton grown by farmers and have not seen any equal to that of No. 15 Risala. Generally there is an apathy to cultivate American cotton as it gives less percentage of lint and requires more care than *deshi kapas*. The Agricultural Farm is striving hard to select such American seed as would suit the climate and give a large percentage of lint and long stapled cotton. During the short time of its existence it has distributed various sorts of American seeds among the farmers and hence the trouble, as many of the American varieties are not suitable to the climate. The farmer also gives the American the same treatment as his *deshi* sorts. As the fibre of the American cotton is very thin and fine, special care is essential in picking and handling. The method of storing the *kapas* is also very defective, and this defect is not only found among the uneducated farmers as I was surprised to see the *kapas* of the Agricultural Farm stored in large, iron cisterns about 15 to 20 feet high. The stuff was not loosely packed but it was pressed hard, a procedure which is sure to spoil the staple and colour and increase the waste in the blow-room. If a proper method is pursued throughout there is a splendid future for American cotton in this district. The soil is rich and, from the farmer's point of view, the soil that gives good wheat can also yield a good cotton crop. It may be that the improvement cannot be achieved in a few years, but the picking can be improved now, if more care be taken. To make the American cotton grown in India commercially successful it is very essential indeed that particular care should be taken in picking. I send you two samples of cotton, both from the same farm (No. 15 Risala) and from the same seed. The only difference between them is that the former was carefully picked and such a sample can be commercially classed as F. G. M.; the latter, though equal in staple and regularity, can be classed between L. M. and Med."

In a further communication Messrs. Tata, Sons & Co. have given me the results of the working of Lyallpur cotton, compared with American, *bani* and *bhuri* types. The

count spun was 24s and in all cases the number of turns per inch was the same.

	Loss per cent. on cotton in blow-room.	Tension of 24s warp.
American F. G. M. Boweds . .	7·75	57·44 lbs.
Panderkora Bani	8·34	60·33 „
Lyallpur	10·08	52·20 „
Bhuri	10·37	46·10 „

The prices at the time of purchase of these respective varieties were very nearly the same in all cases, being about Rs. 130 per *boja* of 345 lbs. laid down at Nagpur.

On this basis, but including the blow-room loss, the purchase prices per lb. work out as follows :—

American	6·5	annas	per lb.
Panderkora Bani . . .	6·53	„	„ „
Lyallpur	6·63	„	„ „
Bhuri	6·65	„	„ „

To conclude with the Punjab, it is necessary to add that Messrs. Tata, Sons & Co. and the Directors of the Bombay Cotton Trade Association have thus remarked on a set of samples submitted to them for opinion by the Economic Botanist : " Only two samples out of the 27, Nos. 161 and 179, can be compared with American. They are splendid cottons, especially in the length and strength of their fibres, and every help and encouragement should be given for their cultivation on an extensive scale. If the cultivation of these cottons turn out a commercial success it will finally solve the problem of obtaining long staple cotton from the British territory. We are afraid, however, that the dream is difficult of realization. The exotic has to contend with the soil and climate as well as with the apathy, indifference, ignorance and prejudice of the Indian cultivator."

The valuations of these samples in order of merit, by the Bombay Chamber of Commerce and Messrs. Tata, Sons & Co., Bombay, are appended. As the outturn and percentage figures are unknown to me it is impossible to say in the absence of these data which if any of them are the most

profitable to grow, and I hope that the Department in the Punjab will be able to furnish the figures necessary for comparison.

Valuation by the Bombay Chamber of Commerce.

BASIS.

Middling American at Rs. 340 per candy of 784 lbs. less 5½ per cent.
Fine M. G. Naosari „ 320 „ „ „ „ „
Good Tinnevelly „ 310 „ „ „ „ „
Fine M. G. Broach „ 290 „ „ „ „ „

All for ready delivery in Bombay.

Valuation by the Bombay Chamber of Commerce, dated the 13th May 1912, on the 27 samples of cotton from Lyallpur, Punjab.

Serial No. (according to merit).	Variety.	Approximate market value per candy of 784 lbs. on May 13th, 1912, less 5½ per cent.	REMARKS.
		Rs.	
1	161	425—450 (Nominal).	Superfine long silky staple. Impossible to give accurate valuation and sample should be sent to Liverpool.
2	280F	380 (Nominal).	Strict fine, long staple and good colour.
3	271	365 (Nominal).	Superfine, good long staple, good colour.
4	274	350 (Nominal).	Strict fine, long silky staple, good colour.
5	246	325	Superfine, long silky staple, good colour.
6	272	320	Strict fine, nice staple and colour.
7	273	320	Fine, rather better staple than 272.
8	72F	320	Superfine in class, long silky staple, good colour.
9	111	320	Strict fine, good staple and colour.
10	168	315	Strict fine, good strong staple.
11	112	312	Strict fine, good strong staple and colour.

Valuation by the Bombay Chamber of Commerce, dated the 13th May 1912, on the 27 samples of cotton from Lyallpur, Punjab. —contd.

Serial No. (according to merit).	Variety.	Approximate market value per candy of 784 lbs. on May 13th, 1912, less 5½ per cent.	Remarks.
		Rs.	
12	126	310	Superfine class, strong staple, good colour.
13	199	310	Superfine, strong staple but not very long, good colour.
14	7F	305	Strict fine in class, nice staple but not very silky, good colour.
15	110	300	Strict fine, good staple, and good colour.
16	267	300	Superfine, staple a little better than 266. Cotton is more bulky.
17	275	300	Strict fine, moderate staple, good colour but leafy.
18	70F	295	Strict fine in class, irregular and rather rough staple, good colour.
19	276	295	Fine, moderate staple, leafy.
20	220	290	About fine, staple strong but rather rough and irregular.
21	266	290	Strict fine, only moderate staple, nice colour.
22	233	280	Strict fine, fair staple but rather rough.
23	270	280	Fine fair staple.
24	226	275	Superfine, rough and short in staple, more like Rajputana cotton.
25	232	270	Fine, rather rough and short in staple, colour not so good as 226.
26	28D	265	Strict fine, poor staple and very wasty.
27	179	..	No sample sent.

Valuation by Messrs. Tata, Sons & Co., Bombay, dated 10th May 1912, on the 27 samples of cotton from Lyallpur, Punjab.

Serial No. (according to merit).	Variety.	Remarks.
1	179	Quite equal to Fully Good Middling American cotton. To-day's (10th July) price will be 8*d.* per lb.c. i. f. Bombay or say Rs. 425 per candy.
2	161	This cotton is far and away the best of its kind grown in Indian soil and acclimatized to the Indian climates. Though not exactly after the American style it is no way inferior to Good Middling. The length of the fibre is fully 1⅛ inch. Good Middling American of 1⅛ inch staple cannot be laid down in Bombay under 7½*d.* per lb. or say Rs. 365 per candy. If you add 5½ per cent. discount allowed in Bombay the cost comes to Rs. 385 per candy. We value this cotton, therefore, at Rs. 385 per candy.
3	271	This cotton is exactly like Naosari in its feel and length of fibre. Value Rs. 340 per candy.
4	274	Equal to the very best Surat. Value Rs. 325 per candy.
5	72F	This has the characteristic and style of the best Surat and being slightly better than 7F in the length of fibre, we value it Rs. 5 more, *viz.*, Rs. 325 per candy.
6	7F	This cotton is of the Surat style. It has a long even fibre like Surat, and the colour and appearance are strikingly like it. It is lacking, however, in the soft silky feel of Surat cotton. We value it in price equal to the best Surat cotton namely, Rs. 320 per candy.
7	111	This is again the best Surat style of cotton equal to 7F. Value Rs. 320 per candy.
8	68	Best Surat style of cotton. Value Rs. 320 per candy.
9	246	Surat style of cotton. Value Rs. 320 per candy.
10	272	Surat style of cotton. Value Rs. 320 per candy.
11	112	It is same as 111, but a shade short in the length of fibre; therefore, we value it Rs. 5 less, say Rs. 315 per candy.
12	270	Surat style of cotton, but slightly shorter in fibre. Value Rs. 310 per candy.
13	273	Surat style of cotton, but slightly inferior in staple. Value Rs. 310 per candy.

Valuation by Messrs. Tata, Sons & Co., Bombay, dated 10th May 1912, on the 27 samples of cotton from Lyallpur, Punjab. —contd.

Serial No. (according to merit).	Variety.	Remarks.
14	276	Broach style of cotton, but a little longer in fibre even than 275. Value Rs. 305 per candy.
15	275	Broach style of cotton, but being slightly longer in fibre than Broach, we value it at Rs. 300 per candy.
16	267	Same as 266 but slightly better in staple. Value Rs. 300 per candy.
17	126	It is midway between the best Broach and Surat. It approximates more to Broach and we value it Rs. 10 more than fine Broach, *viz.*, Rs. 295 per candy.
18	266	Equal to the best Broach cotton. Value Rs. 295 per candy.
19	199	Best Broach style of cotton. Value Rs. 290 per candy.
20	220	This cotton has the style of superior cottons of the Central Provinces, say Warora and Hinganghat. Value Rs. 290 per candy.
21	70F	This cotton has the appearance of the best Broach and the fibre is a shade longer than that of Broach. We value it, therefore, at Rs. 290 per candy, say Rs. 5 more than the price of Broach.
22	110	This cotton resembles the superior grade cottons such as Warora and Hinganghat grown in the Central Provinces. It is slightly dull in colour; therefore, we value it Rs. 5 lower than Warora, *viz.*, Rs. 285 per candy.
23	226	This is of the style of inferior cottons of the Central Provinces, such as Wardha and Nagpur. Value Rs. 285 per candy.
24	233	Wardha or Nagpur style of cotton of the Central Provinces. Value Rs. 285 per candy.
25	232	Best Berars style of cotton such as Yeotmal. Value Rs. 280 per candy.
26	28D	In colour and style like superior Berars, but the fibre is very short and weak; therefore, we value it at Rs. 275 per candy.
27	280F	No sample sent.

Prices fixed upon the following *basis*:—

Bombay candy weighs 784 lbs. The price of cotton in Bombay includes a rebate of 5½ per cent. For example if you purchase cotton, say, at Rs. 300 per candy, the seller allows you a rebate of 5½ per cent. so that the actual price of cotton is Rs. 283½ per candy. Therefore, the prices quoted are subject to a rebate of 5½ per cent.	American Good Middling	7½*d.* c. i. f.		
	„ „ „	Rs. 365	net per candy.	
	Fine Naosari	340	per candy.	
	„ Surat	320	„	„
	„ Broach	285	„	„
	„ Warora-Hinganghat (Central Provinces).	290	„	„
	„ Wardha (Central Provinces)	285	„	„
	„ Yeotmal (Berars)	280	„	„
	Good Tinnevelly	320	„	„

United Provinces.—I visited these in October and toured in the company of Dr. A. E. Parr, the Deputy Director of the Northern Division.

I made the following notes on my inspection of the cottons on the Agricultural Experimental Station at Aligarh :—

(1) *Bhuri* (*G. hirsutum, variety,* originally from Chota-Nagpur). This has grown well, but the yield is low and last year it produced practically no crop. I pointed out to Dr. Parr that the species normally consists of a mixture of a productive and non-productive form, the latter predominating in his plots. If selection is continued by using the former type, he will soon possess a strain of high class cotton suitable for his Division in all respects.

(2) Mr. Leake's selection (white flowered cotton or *G. roseum*) yields well and is a moderately early cotton.

(3) Mr. Leake's selection (broad lobed white flowered cotton, var. *cutchica*) has produced at the rate of 12 maunds of seed cotton per acre and on the score of outturn alone is distinctly promising.

(4) *Kil* or Garo Hill cotton is more productive than the two last named, but our experience is that it deteriorates rapidly to the standard of local types.

(5) Yellow flowered *Neglectum*. This yields a cotton of better staple.

All the field experiments are on the white flowered or *Varhadi* type of cotton. As in other parts of India, owing to its hardiness, high produce and also high percentage of cotton to seed, it is rapidly becoming the favourite variety of the cultivators. Already Dr. Parr has 300 acres under this in seed farms and next year he hopes to increase their area to 3,000 acres. In price of crop it surpasses yellow flowered cotton by Rs. 12 to Rs. 15 per acre. There is little difference in the yield of broad cast and drilled plants. The best spacing distance has been found to be 18 inches between rows and 9 inches in the rows. A yield of 10 maunds of seed cotton per acre has been obtained. White flowered cotton grown with ground-nut yields about half the ordinary unmixed crop. The general practice is to grow cotton with *Cajanus indicus*. Dr. Parr says that in the Aligarh District about half the cotton crop is irrigated. Southwards the proportion of irrigated cotton decreases.

Mr. Graham, the Manager of West's Patent Press at Aligarh, thinks that, so far as cotton improvement is concerned, it would be sufficient to increase the outturn. He also thinks that a better staple should be arrived at. Few traders I have met seem to appreciate the fact that an increased staple in *Bengals* is invariably accompanied by a falling off in yield and percentage of cotton to seed.

After a discussion with Dr. Parr regarding his future line of work we agreed that the following would be most practicable :—

(1) To purify out the white flowered cottons and extend their cultivation as pure types. They have already been tested and proved to be more pro-

ductive and remunerative than the yellow flowered types.

(2) For the present we must conclude that American cotton has had a fair trial and has failed. In some cases it yielded badly and in others it could not meet with a suitable market.

(3) Dr. Parr will continue his experiments with the form of *Bhuri* that I have pointed out to him as being most suitable for the purpose.

(4) The experiments with yellow flowered *neglectums* should be persevered with. The staple is superior and it may prove remunerative to produce the cotton as a pure type. I showed Dr. Parr in the field how to readily distinguish the most productive plants of both white and yellow flowered cottons.

In company with Dr. Parr I visited Kashipur where a particular class of cotton was said to be grown. We found that the cotton was of exceptionally good quality, approaching in appearance and staple, the *Bani* or *Hinganghat*. I have advised Dr. Parr to make all his selections in the tract and not risk damaging the reputation of the local produce by bringing in anything from outside. I have since seen it mentioned in the newspapers that the Department is establishing a seed farm here.

The Tahsildar of Kashipur, Mr. Thakar Raghunathsingh, gave the following information. The rainfall of this tract averages between 40 and 50 inches. Last year it was 64 and this year 36. Last year the acreage under cotton was about 5,000 and this year 4,500. Wild animals from the reserved forests damage all crops excepting cotton. The average yield of seed cotton is 9 maunds per acre and under the most favourable conditions it reaches 12 maunds.

The price of Kashipur cotton is Rs. 2 per maund higher than that of ordinary *Bengals*.

The ginning factory proprietor at Kashipur is extremely anxious that no rough sort should be introduced to spoil the quality of the local fine variety.

I learnt that there are large areas of land suitable for cotton in Kashipur, especially near the reserved forest where the ravages of wild animals render the cultivation of grain crops so uncertain that these parts are relapsing into jungle. The quality of this cotton seems to be so excellent that (as I have already emphasized) all selection should be worked out on the spot and nothing in the way of *deshi* cottons should be introduced, whether they seem superior or not. There is a grand field here ready for growing selected local cottons and I am certain that Dr. Parr will not be slow in developing the possibilities of this tract. That two ginning factories have already been erected on the spot is proof positive of their owner's anticipation that the cultivation of cotton in this favoured tract will ultimately extend largely and rapidly. Personally, I was gratified to discover this tract as I was by then despairing of finding anything in the United Provinces better than ordinary *Bengals*.

The cotton grown round Chandausi is famed for its whiteness and staple. It is grown as a dry crop and sold at a higher price than ordinary *Bengals*.

There is only one variety or type of this known and it is decidedly inferior to Kashipur cotton.

Messrs. Ralli Brothers' agent here informed me that in a good year Chandausi cotton can be classed as Oomras, but that it is very inferior this year. He also considers that on the whole the United Provinces' cottons are inferior to those of Berar. The poorest qualities come from the westward (Beawar for example) and there is a gradual improvement to the eastward.

The United Provinces' cottons consist of the usual mixture of the types yielding *Bengals*, and at Aligarh Farm it can be seen that these types are easily separated.

It is to be regretted that the cultivation of American cottons has failed, but the Department should remember that there is an expressed demand for improved indigenous cottons from traders and manufacturers in the Province itself, which it should attempt to satisfy.

The following are the valuations kindly furnished by Messrs. Tata, Sons & Co., Bombay, on the 5 samples grown at the Agricultural Station, Aligarh, last year :—

Valuation of the samples from Aligarh Agricultural Station (valued on 18th January 1912).

Out of 5 samples, Nos. 1 to 5, sample No. 2 is the best of the lot in point of length of fibre and feel. We value it to-day at Rs. 265 per Bombay candy, or say Rs. 15 more than the price of Fine Bengal (F. Bengal Rs. 245).

No. 3 is slightly inferior to the above in length of staple, value Rs. 260.

Nos. 1, 4 and 5 are all alike and may be valued at Rs. 255.

The above cotton is harsh in feel like wool and resembles Assam cotton. It can be used in mixing with wool as Assam is on the continent, hence it has a special value of its own. This kind of cotton is generally 15 to 20 rupees higher in price than fine Bengal in normal times. We value Assam cotton to-day at Rs. 265 per Bombay candy.

Madras.—I have had no opportunity of visiting this Province during the year, but a letter from Mr. Couchman, Director of Agriculture, to the Board of Revenue, last year, fully explains the situation. From this it appears that in Tinnevelly, the *Karunganni* variety of cotton and in Nandyal the white seeded *Tellapathi* cotton have been proved by field experiments, supported by expert opinion from the mills, to be superior to the mixed field crops of cottons ordinarily grown in the Tinnevelly and Kurnool Districts. To extend the cultivation of these varieties seed farms were opened in Tinnevelly in 1908 to grow *Karunganni* on a large scale. In Kurnool a beginning was made last year with 35 acres of seed farm for growing pure *Tellapathi* seed.

The rapid increase of the area under *Karunganni* showed that the people were keeping the seed themselves. With a view, therefore, to extend the variety to new tracts, 43 seed depôts were opened, many of them in new tracts,

as the tracts in which some of the depôts were opened in previous years had now become pure *Karunganni* tracts.

Very gratifying evidence is now forthcoming to show the value of this crop to the cotton trade of the district. In two cases, new ginning factories have been opened by export firms, in localities where pure *Karunganni* has been introduced on account of the fine quality of cotton now obtainable there.

The large distribution of seed by the Department has made the Tuticorin Circle practically a pure *Karunganni* tract. Messrs. Volkart Brothers write :—"We have during the last few years noticed that a relatively very good cotton is received from places near Koilpatti, including the railway stations of Nalaturputtur, Kumarapuram and Kadambar. We have no hesitation in concluding that your experiment has been highly satisfactory in its results. The cotton from these places fetches a better price and is better liked by spinners both in Europe and the East than the bulk of Tinnevellies which are marketed further north at Virudupatti, etc."

Messrs. Ralli Brothers also state that there has been a marked improvement in the quality of Tinnevelly cotton during the last few years, especially in the Tuticorin Circle.

This independent evidence from the large buyers is most encouraging as it shows that an appreciable improvement can be effected in a short time to the whole crop of the tract by the methods worked out by the Department.

In the Northern Circle there was a keen demand for the farm seed which gives better crops than the seed available from the usual sources.

There is also a large demand for Cambodia seed, but this season there is a disquieting report to the effect that it has deteriorated in staple so that manufacturers cannot spin the usual counts from it. An enquiry into this matter has already been instituted.

Valuation of the 17 samples of cotton from Koilpatti (Madras) furnished by the Bombay Chamber of Commerce, on the 18th April 1912.

Serial No. (according to merit).	Description.	Approximate market value per candy of 784 lbs., less 5½ per cent. discount.	Approximate market value per candy of 784 lbs., less 5½ per cent. discount.	REMARKS.
	Uppam Variety.	Local value.	Export value.	
		Rs.	Rs.	
1	Uppam—Ordinary field crop . .	283	283	These samples are all disappointing in so much as the staple is harsh and rather like Rajputana cotton (Bengals).
2	Pedigree Uppam	280	280	
3	Do.	280	280	
4	Uppam—Ordinary farm crop . .	280	280	Staple very harsh and short.
5	Pedigree Uppam . . .	275	275	Same remark as for Nos. 1, 2 and 3.
	Karunganni Variety.			
1	Pedigree Karunganni . . .	335	Export value nominal.	Nice style with long silky staple.
2	Do. do. . . .	335		Long silky staple and very good spinning cotton.
3	Do. do. . . .	330		Nice staple, good style.
4	Karunganni—Ordinary field crop .	330		Very good staple.
5	Do. do. .	325		Very good staple.
6	Pedigree Karunganni . . .	325		Long staple and good style.
7	Karunganni—Ordinary farm crop .	320		Good staple.
8	Do. Ordinary field crop .	315		Good staple.
9	Do. do. .	310		Very bright clean cotton, but staple not nearly as good as the others ; rather short.
10	Pedigree Karunganni . . .	300		Nice style, good silky staple.
11	Do. do. . . .	295		Nice style good staple.
12	Selected Karunganni . . .	280		Short staple.

The export valuations are rather nominal owing to the large supplies of Americans this year at reasonable rates

compared with Indian cotton. The demand from Europe is for lower priced cotton with fair staple.

	Rs.
Basis.—Fine M. G. Broach	290
Fine M. G. Naosari	330
Fine G. F. Tinnevelly	310
Fine M. G. Bengal (Rajputana)	265
Fine M. G. Akola	275

Valuation of 8 samples of cotton from Bellary (Madras), furnished by the Bombay Chamber of Commerce, on the 31st May 1912.

Serial No. (according to merit).	Historical Description.	Approximate market value per candy of 784 lbs., less 5½ per cent. discount on 29th May 1912.	Remarks.
		Rs.	
1	Kappas and Lint of No. 3. Grown at Bellary Farm this year. This is a selection made in 1906-07 from a sample of Broach seed obtained from Surat.	295	Strict fine in class too yellow in colour for Broach description, staple about equal to Broach and quite as silky. Colour of the kappas is white but the cotton has a yellow tinge.
2	Kappas and Lint of No. 41. These are single plant-selections from the local cotton made in 1908-09. Grown at Bellary Farm.	288	Better in staple than No. 21.
3	Kappas and Lint of No. 21. Grown at Hagari Farm. This is an inter-cross of the local cotton.	285	Class as good as No. 11; staple a good deal better.
4	Kappas and Lint of No. 5. Grown at Bellary Farm this year. This is a selection made in 1906-07 from Kumpta-seed.	280	Has not got the usual Kumpta characteristics, class strict fine, fair to good staple.
5	Kappas and Lint of No. 11. An inter-cross of the local cotton. Grown at Hagari. The selection was made in 1906-07.	278	Class rather lower than No. 10, but staple better.
6	Kappas and Lint of No. 10. An inter-cross of the local cotton. Grown at Hagari. The selection was made in 1906-07.	275	Brighter and whiter than No. 9, staple also better but irregular.
7	Kappas and Lint of No. 44. Single plant, selection made in 1908-09 from the local cotton. Grown at Bellary Farm.	275	Class strict fine, but staple not so good as Nos. 11, 21 and 41.
8	Kappas and Lint of No. 9. Grown on Bellary Farm. This is an inter-cross of the local cotton. The selection was made in 1906-07.	265	Disappointing in staple and decidedly inferior in style to the ordinary Westerns and has not the same bulk, but class much better.

	Rs.
Basis.—Tinnevelly	295
Fine M. G. Broach	280
Good M. G. Kumptas	285
„ „ Westerns	270

Mysore.—In the Mysore State preliminary steps have been taken to establish the cultivation of higher class cotton in non-cotton growing areas and we expect that valauble assistance will be renderd in this direction by the co-operation of the European planters.

North-West Frontier Province.—In consultation with Mr. Robertson Brown it has been arranged that he is to grow large plots of his cottons and that I shall visit his farm when the crops are ripe, to arrange, on the spot, the line of future work he should take in hand.

He gave the following information in a letter to the Inspector General of Agriculture (now the Agricultural Adviser to the Government of India) : "I have just visited a tract in the Peshawar District which is famous in the North-West Frontier Province as producing heavy crops of high class cotton. I was accompanied by the Revenue Assistant, who fixes revenue, etc., so my information is correct. I found that the *banias* in purchasing the crops pay for 6 maunds and take their chances of profit on the outturn beyond that weight. Good average cotton fields in the tract yield 16 maunds per acre and 20 maunds is occasionally produced. I have not seen such heavy outturns of cotton recorded as being produced elsewhere in India, and I am writing to you to find if equally good crops are yielded in any other part. The soil is deep red alluvium and the tract irrigated very sparingly and irregularly from the rich, muddy, Bara River."

Lalio cotton, in the Bawla Taluka, in the Ahmedabad District, under two or three waterings in light soils, is said to yield as high as 1,600 lbs. *kapas* per acre, but the high returns quoted by Mr. Robertson Brown, so far as I know, must be unequalled elsewhere in India.

The following report on a sample of Mr. Robertson Brown's cotton has been received from Messrs. Tata, Sons & Co. :—

> "In all its characteristics it is Oomra style of cotton. Comparing it with Fine Akola ginned at Rs. 275 we value the sample at Rs. 270 as it

is slightly shorter in fibre. We quote Sind Punjab cotton to-day at Rs. 270. Though the sample is from the North-West Frontier Province it cannot be compared with Sind Punjab as the latter is whiter in colour but short in staple and coarse to the feel. The sample examined is of a dull white colour like Akola, the staple is longer than that of Sind Punjab and has better feel."

Experiments with Bhuri cotton on the Khetri Estate in Rajputana.—The seed was given by me for experiment to the Munsarim of this estate who has been courteous enough to furnish a report of his results. I may mention that such thoughtfulness is rare amongst my numerous correspondents. Two and half seers of seed were sown in an acre of land, the plants were spaced $1\frac{1}{2}$ foot apart and the land was watered four times before the rains and twice after the rains. The area consisted of garden land of the first class and the cotton finally collected weighed $2\frac{3}{4}$ maunds.

Messrs. Tata, Sons & Co. kindly furnished the following valuation on a sample of the cotton submitted to them :—

"*Bhuri.*—This cotton has vastly improved and is better than the best cotton grown in India, *viz.*, Naosari. The fibre is very long and is stronger than that of Naosari cotton. On the basis of Naosari at Rs. 335 we value it at Rs. 350 or fully Rs. 15 more per candy."

Arrangements are being made for a more extended trial with *bhuri* in the same locality during the present season. Rajputana appears to offer strong inducements for the production of higher class cottons, but it is difficult to get into touch with its people. I have reason to believe, however, that there is a spontaneous introduction of *bhuri* cotton into the States from Berar.

Bombay.—The following are some of the definite conclusions which have been arrived at in this Presidency :—

At Surat it has been decided to make a reduction in the number of varieties so as to simplify the work, and to discontinue the cultivation of tree cottons as not one has given a useful result.

At the Ganeshkhind Botanical Garden it has been proved that Bourbon only lasts for 6 years which is far short of the 20 years of life claimed for it.

At Dhulia it has been found that the white-flowered *Varhadi* excels in yield and ginning percentage. It has produced 1,500 lbs. of seed cotton per acre, of a value of over Rs. 200. Comparing price and outturn it easily outstrips in value all other Khandesh or Berar cottons. *Karkeli*, although of very high quality, does not yield sufficiently well to be remunerative.

At Dharwar, Cambodia cotton has not continued to be immune from red leaf blight. Mr. Main has arrived at the following conclusions regarding it :—

(1) Cambodia cotton can be grown most profitably in the early part of July in spite of the liability of early sown cottons to red leaf blight.

(2) The early sown crop begins to flower about the middle of November, but these flowers drop off and bolls do not set till December-January.

Bhuri again did badly. It suffered from the red leaf blight believed to be the disease known as the Mosaic in the United States of America. It appears to be less suitable than Cambodia for the conditions obtaining at Dharwar.

At the Gadag Farm, Cambodia Cotton has been proved to be the most suitable substitute for Dharwar American cotton in the eastern part of the Dharwar District, as it surpasses it in yield and ginning percentage.

The trials with numerous American cottons show that they all require considerable acclimatization. Mr. Main also finds that the green fuzz of the seeds of certain Dharwar American plants is not a fixed character as a number of white fuzz seeded plants are produced from green fuzzed

seed. On the other hand, white fuzzed seed appears to be a fixed character and such seed breeds true. These facts lead him to suppose that the colour of the fuzz may be a character which conforms to Mendelian laws. Experiments are still being persevered with towards the introduction of cotton into areas of land, lying waste partly owing to the damage liable to be caused by wild pigs. It is observed that cotton is not touched by these animals.

It is gratifying that the demand for Naosari and Cambodia cotton seeds is steadily increasing in the Karnatic. During the year under report both these cottons maintained higher ginning percentages and at the auction sale realized as in previous years more encouraging prices than the local Kumpta and Dharwar American as shown in the statement below :—

Variety.	Ginning percentage.	Value per naga of 1,344 lbs.
Broach (from Naosari seed) .	33	Between Rs. 170 and Rs. 203 according to grades.
Kumpta	27	Rs. 140.
Cambodia	37	Between Rs. 188 and Rs. 206 according to grades.
Dharwar American . .	30	Between Rs. 140 and Rs. 145.

At Mirpurkhas in Sind, the highest yield of Sindhi cotton was 1,304 lbs. per acre, the second best was at the rate of 960 lbs. per acre. This is compared with 1,683 lbs. seed cotton obtained in the previous year and with 1,280 lbs. in 1907. The best results have always been obtained from April sowings of cotton.

Some valuations by Messrs. Tata, Sons & Co. of cottons grown on the Agricultural College Farm, Poona, are interesting as they demonstrate two points : first, the influence of an unsuitable environment on cottons which require a better

soil and climate, and second, the ease with which the different types of "Bengals" can be separated.

No. 1. *Broach.*—From seed imported from Naosari in 1911. "This cotton grown from Naosari seed on Kirkee Farm is not exactly like Naosari cotton. It is decidedly superior to Broach and is equal to Surat cotton. Value Rs. 310 (Naosari at Rs. 330 per candy)."

No. 2. *Varhadi.*—Seed obtained from Akola in 1911. "This cotton is equal to short stapled Oomra. Value Rs. 255."

No. 3. *Bhuri.*—Seed obtained from Akola in 1911. "This cotton is superior to No. 1, and we class it as best Naosari. Value Rs. 330."

No. 4. *Cambodia.*—Seed obtained from Gadag in 1911. "This cotton is equal to best Surat. Value Rs. 320."

In Nos. 5, 6, 7 and 8, the seed was obtained from Akola five years ago and was sown just as it was. The types were separated out on the farm from this mixture and grown separately in succeeding years.

No. 5.—(Yellow flowered, broad lobed *neglectum*, from Dhulia mixture.)—"Dhulia seed gives improved cotton in Kirkee soil. It has produced cotton equal to Ghat Akola, good staple. Value Rs. 285."

No. 6.—(Yellow flowered, narrow lobed, from the same mixture.)—"Slightly inferior to No. 5. Value Rs. 280."

No. 7.—(White flowered, broad lobed, from the same mixture.)—"This cotton equals the lowest grade Khandesh and is very poor in staple. Value Rs. 245."

No. 8.—(White flowered, narrow lobed, from the same mixture.)—"This cotton equals ordinary Khandesh, and is very poor in staple. Value Rs. 255."

Basis of valuation on 10th July 1912 :—

	Rs.	
Naosari	330	per candy.
Surat	310	„
Broach	290	„
Akola	275	„
Khandesh	265	„

Judging from the valuations received from Messrs. Tata, Sons & Co., the Kumpta cotton from the Sangli State in the Southern Mahratta Country fetches a higher price than that of the same country to the southward. There are presumably highly favourable conditions of soil and climate in this State and the Department of Agriculture, Bombay, may see its way to investigate the possibilities of this tract as a seed distributing centre of Kumpta cotton.

The suspicions of Messrs. Tata, Sons, that the labelling of the bags was transposed, is not confirmed.

The Agricultural Superintendent of the State had grown Broach from seed imported from Naosari and the Kumpta was from an *inter se* cross.

The following are Messrs. Tata's valuations and remarks (on 11th March 1912) :—

"*Sample No. 1.*—Broach cotton grown at Sangli from the seeds imported from Naosari. The cotton shows much improvement, both in colour and staple. Though a slight tinge of red can be detected, the colour is more than fine. On the basis of Rs. 330 for Naosari cotton, we value this at Rs. 340 per candy.

"*Sample No. 2.*—Local (Kumpta) cotton crossed *inter se*. This is really a beautiful cotton, soft and silky in feel with a strong and even fibre, equal to, if not better than, Naosari cotton in length. It is more like indigenous Naosari cotton than like Kumpta. In fact we were in doubt whether a mistake had not been made in bagging the samples. It is really better than No. 1 in all respects and we value it at Rs. 20 over No. 1, *viz.*, Rs. 360 per candy.

"The Sangli soil appears to be eminently suited to the growth of Kumpta cotton, crossed *inter se*, and it is worth experimenting with on a large scale."

The Native States of Palitana and Rajkot in Kathiawar have been supplied with cotton seeds of varieties at their request and the results will be watched with interest.

Valuations.—All samples received were submitted to Messrs. Tata, Sons & Co., Bombay, for valuation; and cordial acknowledgment is due to them for their kindness and promptitude in giving opinions on cottons whenever submitted to them.

A few samples were also submitted to the Bombay Chamber of Commerce to whom thanks are also due.

Programme of work for 1912-13.

It is proposed to tour in the North-West Frontier Province in the autumn to advise on the possibilities of improvement of cultivation and introduction of suitable superior varieties. Tours will also be made in the Bombay Presidency and the Central Provinces and to other parts also, if my services are called for to continue the investigation into the conditions which affect the production of cotton. This enquiry is also carried on wherever touring is done.

In addition I shall continue my special researches in the botany and cultivation of cotton.

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REPORT

OF THE

Agricultural Research Institute and College, Pusa

(Including the Report of the Imperial Cotton Specialist)

1912-13

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Report of the Agricultural Research Institute and College, Pusa,

(*Including the Report of the Imperial Cotton Specialist*)

1912-13.

REPORT OF THE DIRECTOR

(JAMES MACKENNA, M.A., I.C.S.)

I.—CHARGE AND STAFF.

Charge.—Mr. Bernard Coventry, who was, on the 14th June 1912, appointed a Companion of the Most Eminent Order of the Indian Empire, held charge of the office of Agricultural Adviser to the Government of India and Director, Agricultural Research Institute, Pusa, up to the 6th March 1913, when he proceeded on ten months' combined leave, and I was appointed to officiate for him.

Mr. A. C. Dobbs, Assistant to the Agricultural Adviser to the Government of India, returned on the 4th November 1912 from the six months' combined leave granted to him.

Staff.—The Chemical Section remained in charge of Dr. J. Walter Leather, V.D., Ph.D., F.I.C., throughout the year.

Mr. H. E. Annett, B.Sc., M.S.E.A.C., F.C.S., Supernumerary Agricultural Chemist, continued to officiate as Agricultural Chemist, Punjab, until 13th November 1912, when he proceeded on two months and 15 days' privilege leave combined with study leave for ten months and four days. The study leave was granted to enable him to

take a course in Biological Chemistry at Cambridge University or some other institution and visit Agricultural Experiment Stations in England and Germany in order to keep in touch with the most recent work, and incidentally to improve his knowledge of German.

Mr. A. Howard, M.A., A.R.C.S., F.L.S., held charge of the Botanical Section up to the 28th April 1913, when he proceeded on six months' combined leave. Mrs. Howard, M.A., his Personal Assistant, accompanied him. From 8th May to 26th September 1912, Mr. and Mrs. Howard were, as in the previous two years, at Quetta in connection with the development of the Fruit Industry in Baluchistan, an arrangement the continuation of which for a further period of three years (*i.e.*, up to the end of 1916) has been sanctioned by the Secretary of State for India. During their absence, the Second Assistant of the section has held charge of current duties at Pusa and the Third Assistant of the current duties at Quetta. During the year under report, Mrs. Howard was awarded the *Kaisar-i-Hind* Medal of the First Class for public service in India.

Dr. E. J. Butler, M.B., F.L.S., resumed charge of the Mycological Section on his return from privilege leave on July 7th, 1912.

Mr. F. J. F. Shaw, B.Sc., A.R.C.S., F.L.S., Supernumerary Mycologist, was transferred to Coimbatore on April 21st, 1913, to act as Government Mycologist, Madras.

The Entomological Section was in charge of Mr. A. J. Grove, M.Sc., Supernumerary Entomologist, till 29th July 1912, when Mr. H. Maxwell-Lefroy, the Imperial Entomologist, returned from leave. Mr. Lefroy, however, resigned his post on the 30th November 1912 and Mr. Grove was appointed to officiate as Imperial Entomologist. Mr. T. Bainbrigge Fletcher, R.N., F.E.S., Entomologist to the Government of Madras, has been nominated for appointment as Imperial Entomologist. He will take up his duties at Pusa as soon as his successor arrives in Madras.

Mr. F. M. Howlett, B.A., F.E.S., continued in charge of the Pathological Entomological Section throughout the year except for a month and a half in September and October 1912 when he was on privilege leave.

The Bacteriological Section was in charge of Mr. C. M. Hutchinson, B.A., throughout the year excepting three weeks in September-October 1912, when he was on privilege leave.

Mr. J. Hugh Walton, B.A., B.Sc., joined the staff as Supernumerary Agricultural Bacteriologist on 25th October 1912.

The Agricultural Section continued in charge of Mr. S. Milligan, M.A., B.Sc., throughout the year with the exception of one month in September 1912, when he was on privilege leave.

None of the Supernumerary Agriculturists worked at Pusa; Mr. G. D. Mehta, L.Ag., B.A., N.D.A., N.D.D., was under training in the Central Provinces; Mr. N. S. McGowan, Dip. in Agric. (Cantab.), continued to act as Deputy Director of Agriculture, Bihar and Orissa; and Mr. T. Gilbert, B.A., Dip. in Agric. (Cantab.), has been working under the Bombay Government.

II.—Work of the Institute.

Scientific Work.—An account of the scientific work of the Institute during the year is given in the reports of the several sections.

Training.—The training of students on the lines laid down in the Prospectus was continued, and short courses were also given in Cattle management, Sericulture and Lac culture.

During the year under report, five students were under training in Agricultural Chemistry. Of these one Government stipendiary deputed by the Bengal Department of Agriculture, and one private student from the Central Provinces resigned. One Government student deputed by the Agricultural Department of Bihar and Orissa was

recalled for duty at the Agricultural College, Sabour, before the completion of his course. The remaining two students (a Government stipendiary from the Travancore State and a private student from Madras) continued their course.

A private student from Madras was admitted to the post-graduate course in Economic Botany on 1st October 1912.

The Entomological and Mycological collector deputed by the Agricultural Department of Bihar and Orissa, and referred to in last year's report, was under training in the Mycological Section until August 17th, 1912, when his course was terminated as he was found unfit for further training.

In the Entomological Section, the student deputed by the Department of Agriculture, Travancore, continued his training, and a student deputed by the Assam Department of Agriculture was admitted on November 1st, 1912, to the post-graduate course. An Agricultural Assistant of the School of Agriculture, Giza, deputed by the Egyptian Government, was given three months' training in practical Entomology.

Besides the regular students mentioned above, the following visitors to the Institute worked in the Entomological Laboratory during the year :—

Dr. L. H. Gough, Entomologist to the Department of Agriculture, Egypt, in September 1912, in connection with the boll-worm parasite.

Mr. A. Alfieri of the Khedivial Agricultural Society of Cairo from July to September 1912, in connection with the boll-worm parasite.

Lala Bishember Das, Assistant Professor of Biology, Government College, Lahore, from October to December 1912.

Lala Madan Mohan Lal, Assistant Professor of Entomology, Agricultural College, Lyallpur, for three weeks during October 1912.

The Entomological Assistant of Baroda came to Pusa in April 1913 to discuss the programme of his work for the ensuing year. The Weaving Expert to the Government of Bengal and the Principal of the Weaving School, Benares, inspected the work of the Silk-House at Pusa.

A course of instruction in identification, breeding and general observation of *Stegomyia* was given by the Imperial Pathological Entomologist in July 1912 to Medical Officers engaged in the "Stegomyia Survey."

A probationary research Assistant under the Agricultural Chemist to the Punjab Government was deputed to this Institute to undergo training for one year in Bacteriological methods. He joined the Bacteriological Section on 13th August 1912.

As the existence of facilities at Pusa for post-graduate study becomes known, there is a steadily increasing number of enquiries concerning them, and towards the end of the year under report several applications for admission were received from private students. Every encouragement is given to such students, and it is hoped that the thorough training they can obtain at Pusa will enable them, on leaving, to secure remunerative employment in the special lines they have taken.

During the year under report, 19 students attended the short courses—three in "Cattle management," nine in "Sericulture" and seven in "Lac cultivation." Most of these students came from the Native States of Travancore, Bhopal, Karauli and Mysore.

III.—Publications.

Publications.—The issue of the Journal, Memoirs and Bulletins was continued. The demand for the Journal and Bulletins, which deal in a popular way with matters of practical interest, is steadily increasing. The Department published, during the year, 19 Memoirs and 5 Bulletins; against 14 Memoirs and 4 Bulletins in the previous year. The Provincial Departments continue to

supply an increasing number of contributions for these publications.

The first bacteriological memoir was published during the year, the section having been comparatively recently organised.

A Veterinary Series was added to the scientific memoirs of this Department during the year under review, and three issues were published during the year. Two more are in the press. This series of memoirs is open to receive papers from all members of the Civil Veterinary Department and other workers in Veterinary Science in India. It has also been decided to publish as Bulletins of this Institute, veterinary papers which are unsuited for publication in the Agricultural Journal of India or in the veterinary series of scientific memoirs. One such was published as Bulletin No. 32.

The Government of India have sanctioned a permanent annual grant of Rs. 29,000 for the agricultural and veterinary publications issued by the Imperial Department of Agriculture. As a result of the expansion of departments and the greater experience on the part of the staff, the number of publications continues to increase and it has been necessary to exercise the greatest economy in connection with publications.

IV.—General Administration.

Buildings and Works.—During the year under report the Government of India sanctioned the construction of two additional bungalows for European officers, the extension of the library and the extension of the Director's office building. A proposal to install electric lights and fans in the European bungalows and the Guest House at Pusa, and to work the farm machinery electrically, is under consideration.

Library.—The third edition of the catalogue of the library is under preparation. The library is rapidly becoming overcrowded, and during the year over a thousand volumes have been added, besides several foreign bulletins,

memoirs, reports, etc. An ever-increasing number of agricultural publications is received in exchange from all parts of the world.

Pusa Middle English School.—In November 1912, a Government Middle English School was established within the Pusa Estate for the education of the children of the subordinate staff of the Institute. The school is also open to the public in the surrounding villages. Plans and estimates for the school building and for quarters for teachers, are under the consideration of the Government of Bihar and Orissa, and the school is at present located in temporary quarters. As the Middle English School does not meet the requirements of the staff at Pusa, proposals have been submitted to the Government of India for raising the present school to the status of a High School and also for the establishment of a Girls' School at Pusa.

General Health of the Station.—The general health of the station during the year under report was, on the whole, very good. Medical relief was afforded to 8,538 new cases of which 8,333 were treated in the out-patients' department of the hospital and 205 were admitted as indoor patients. One hundred and eighty-three cases amongst European officers and their families were attended to. The daily average number of patients treated was 52·73 outdoor and 9·64 indoor.

Three deaths occurred in hospital, one from Debility (old age), one from Empyema and one from Malarial Cachexia.

An epidemic of cholera, which broke out in the villages in the immediate vicinity of Pusa during the months of April, May, and June, threatened to be a source of great danger. The disease entered the Estate during the earlier part of the outbreak and one man was attacked, but recovered. Immediate and successful measures were adopted, including the thorough cleansing and disinfection of all the wells on the Estate, to prevent the spread of the disease.

One hundred and forty-one surgical operations were performed, of which thirty were major, and one hundred and eleven minor.

The number of Estate cases treated for malarial fever was considerably less than during the previous year; this was most probably due to the fact that the inhabitants were more willing than heretofore to take quinine prophylactically towards the close of the monsoon.

Eleven primary vaccinations and five re-vaccinations were performed during the early part of the year.

Lieutenant-Colonel F. J. Drury, I.M.S., Inspector-General of Civil Hospitals, Bihar and Orissa, visited Pusa on the 7th December 1912 and inspected the Hospital and the medical arrangements. He has recommended the addition of a Female Ward to the Hospital, and proposals for its construction are under consideration. The Government of India have recently sanctioned the appointment of a midwife to be attached to the Hospital.

V.—Accounts.

The total expenditure during the financial year 1912-13 was Rs. 4,00,077 as under :—

	Rs.
Office of the Agricultural Adviser to the Government of India and Director of the Institute	1,43,509
Chemical Section	34,828
Mycological Section	39,650
Entomological Section	36,914
Pathological Entomological Section	26,641
Botanical Section	36,099
Bacteriological Section	23,783
Agricultural Section	58,653
Total	4,00,077

The above amount of Rs. 4,00,077 included expenditure under the special grant of Rs. 10,000 placed at the disposal of the Agricultural Adviser for special Agricultural Experiments.

The principal items of expenditure under this special grant were as under :—

	Rs.
(1) Experimental cotton cultivation conducted by the Imperial Cotton Specialist	2,000
(2) Contribution towards the pay of the Flax Expert engaged by the Bihar Planters' Association for 1912-13 . . .	2,750
(3) Purchase of special agricultural implements and machinery	2,210
(4) Saltpetre experiments carried on by the Imperial Agricultural Chemist . .	380
(5) Poultry Experiments at Pusa . . .	1,210

The budget of the Agricultural Adviser also includes a grant of Rs. 1,10,000 for meeting the expenditure for three years from 1911-12 in connection with the engagement of Mr. W. Hulme as Sugar Engineer in the United Provinces for the development of the Indian Sugar Industry; and a grant of Rs. 15,000 for payment to the Indian Tea Association as a grant-in-aid.

In March last, the Government of India provisionally allotted, out of the surplus of Imperial Revenue, a sum of Rs. 60,000 for improvements connected with the Pusa Institute. This special grant will be mainly utilised for the purchase of steam cultivating machinery and labour-saving appliances, the extension of the library, the development of the fruit work at Quetta, the testing of milling and baking qualities of wheats, bacteriological investigations in connection with rice cultivation, the demonstration of improved methods of saltpetre refining, the construction of a potculture-house for mycological investigations and other minor improvements.

The gross receipts during the year by sale of farm produce, milk, and other miscellaneous articles, amounted to Rs. 14,663 as against Rs. 9,455 of the preceding year.

VI.—Visitors.

The Hon'ble Sir Charles Stuart Bayley, K.C.S.I., I.S.O., Lieutenant-Governor of Bihar and Orissa, visited

the Institute on the 31st January 1913. His Honour took this opportunity to invest Mr. Bernard Coventry with the insignia of the "C.I.E." and to present the *Kaisar-i-Hind* Gold Medal for public service in India, to Mrs. Howard, M.A., Personal Assistant to the Imperial Economic Botanist. His Honour was accompanied by Lady Bayley and the Private Secretary, and the party included the Hon'ble Mr. E. V. Levinge, C.S.I., Member of the Board of Revenue; the Hon'ble Mr. H. LeMesurier, C.S.I., C.I.E., Chief Secretary to the Government of Bihar and Orissa; the Hon'ble Mr. F. N. Fischer, I.C.S., Commissioner, Tirhut Division; Mr. W. B. Heycock, I.C.S., Director of Agriculture, Bihar and Orissa; and Mr. A. H. Vernede, I.C.S., Collector of Darbhanga.

During the year under report the Hon'ble Sir Harcourt Butler, K.C.S.I., Member-in-Charge of the Education Department of the Government of India; Sir Krishna Gobinda Gupta, K.C.S.I., Member of the Secretary of State's Council; Mr. H. N. Ridley, C.M.G., M.A., F.R.S., F.L.S., F.R.H.S., retired Director of Gardens, Singapore, and many others, also visited the Institute.

REPORT OF THE IMPERIAL AGRICULTURIST

(S. MILLIGAN, M.A., B.Sc.)

I.—ADMINISTRATION AND TOURS.

Charge.—I held charge of the section throughout the year with the exception of one month spent on privilege leave in September.

Supernumerary Establishment.—None of the Supernumerary Establishment have worked under me during the year.

Mr. G. D. Mehta, Supernumerary Agriculturist, who was on deputation under the Government of Bombay, is now under training in the Central Provinces.

Mr. N. S. McGowan, Supernumerary Agriculturist, is working as Deputy Director of Agriculture, Bihar and Orissa, from 23rd February 1912.

Mr. T. Gilbert, Supernumerary Agriculturist, is at present working under the Bombay Government.

Staff.—Mr. Judah Hyam continued in charge of the breeding herds. He was on privilege leave from 2nd January 1913 to 4th February 1913, during which period Mr. L. S. Joseph, Veterinary Assistant, acted for him.

Mr. Mohamed Ikramuddin held the post of First Farm Overseer throughout the year. He has performed his many and varied duties satisfactorily.

Mr. Mohamed Ziauddin Hyder worked as Second Farm Overseer until 15th May 1913, when he left this department on transfer to the United Provinces Agricultural Department.

Babu Kshiti Bhusan Mukerji, Senior Fieldman, left Pusa on 11th February 1913 on transfer to the Bihar and Orissa Agricultural Department.

Babu Brajraj Mukerji was promoted to the post of Senior Fieldman from 11th February 1913.

Tours.—During the year I made several short tours in Bihar and conducted the final examinations in Agriculture at Coimbatore and Lyallpur in March and April.

Training.—Three students were instructed in cattle breeding.

II.—Farm Cultivation.

Character of the Season.—The rainfall during the year amounted to 41·26″ (*i.e.*, from 1st May 1912 to 30th April 1913) as against 53·49″ last year.

Monsoon rainfall began early and continued normal up to the second week in July. The bad effects of a prolonged break during the latter half of that month were mitigated by fairly well distributed rains in August. The September and October rainfall was, however, far short of normal. Late rains in November and February, however, improved the rabi crops considerably. The season was thus unsuitable for rice, sugarcane, maize and wheat, but fairly good for such crops as *sarson*, oats, etc.

Cropping.—The present double cropping system appears to require the application of organic manures at more frequent intervals to ensure maximum yields. During the present year owing to the scarcity of rainfall in September and October no increase was obtained in the wheat crop succeeding a green manuring with sunn hemp. The manure evidently became available at too late a date to affect the grain outturn.

The following crops were grown :—Sugarcane, maize, wheat, *sarson*, *guar*, turnips, oats, gram, linseed, lucerne, paddy, *mung*, *joar*, *khesari*, oats and peas, *arhar*, Florida velvet beans, sweet potatoes, *kudzu* (a Japanese fodder), guinea grass, *bajra*, cowpeas, castor, indigo and jute.

Experimental Cultivation and Implements.—Suitable methods of sowing and inter-cultivating sugarcane and maize have been worked out. The most economical spacings for these crops are under investigation. Implements suitable for inter-cultivation are under trial. A year's experience of the heavier low-lying area has demonstrated the

great superiority of revolving harrows and sectional rollers over drag-harrows and levelling beams for dealing with this class of land.

The permanent manurial experiments have been continued.

The green manuring experiments in collaboration with the Imperial Agricultural Bacteriologist have been altered in conformity with last year's experience.

The use of crude khari salt for rice.—This salt was applied as in last year's experiments in September, but on account of the dryness of the soil had little effect.

Artificial sprouting of sugarcane.—This practice proved useful against the attacks of termites.

Fodder.—The following fodder crops have been under observation :—Guinea grass, lucerne, *kudzu.*

III.—Live-stock and Poultry.

Breeding Herd.—During the year 13 cows and 22 young cattle have been sold.

Present numbers are :—

	Cows.	Bulls.	Young stock.
	89	3	137
as against	74	5	118

at the same date last year.

During the last two years an attempt has been made to train the young cows to give milk without the presence of their calves. The result has been very disappointing and the practice has had to be abandoned.

The average milk production of the herd has improved considerably owing to a more rigid selection of the cows. This year's additions have been all tested previous to purchase with regard to their milking qualities.

Tuberculin Test.—The milk cows were for the first time subjected to the Tuberculin Test by the local Veterinary Department. None reacted.

Sheep.—The lambing period has been regularized and limited with satisfactory results. Crossing with Dhumba and half-bred Gorakhpore Dhumba rams has been continued. Two Merino rams have been imported for the improvement of the quality of the wool. Some time must elapse before results of any value can be obtained. The first cross between the Gorakhpore and Dhumba breeds, however, results in an improved mutton sheep. Gorakhpore ewes are still used as the female parents in these experiments.

Poultry.—The three breeds, White Wyandotte, Buff Orpington and Chittagong, having proved the hardiest and best generally of the large number of varieties tried at Pusa, it has been decided to maintain these and the Mammoth Bronze Turkeys on certain of the Provincial farms and they are being distributed accordingly; new blood will be supplied from England when necessary. The only breed maintained at Pusa in the immediate future will be the Buff Orpingtons.

IV.—Pastures.

Pastures.—A great improvement has been made in the grazing of both the low-lying and higher pasture areas through topping the grasses before seeding time with hay mowers and occasionally harrowing down the cattle droppings. The effect of rolling, except on newly laid out pastures, is slight.

The economics of laying land down to pasture are being studied. A collection of the more valuable indigenous pasture grasses has been made. These are at present being grown as pure cultures.

V.—Clearing and Levelling.

Clearing and Levelling.—Thirty acres of land in the low-lying brick-field area have been reclaimed. A considerable amount of levelling has been done in the more suitable fields with a view to increasing the experimental area which is at present very inadequate.

VI.—Programme of work for 1913-14.

Permanent Experiments.—These experiments will be continued. In the low-lying area gram will be substituted for *arhar* in the leguminous rotation on account of the liability of the latter crop to suffer from waterlogging in the rains. In the higher area gram will be alternated with *arhar*. To the green manuring series a plot will be added in which superphosphate is applied to the green manure.

A special study of the maintenance of soil fertility under a double and single cropping rotation will be made.

Field experiments on green manuring in collaboration with the Imperial Agricultural Bacteriologist will be continued.

New Crops.—A special area is being prepared for the trial of new crops.

Cultivation.—Special attention will be paid to the improvement of methods of cultivation of the sugarcane crop, including subsoiling and the improvement of local drainage.

New methods of dealing with heavy soils will be tried.

The improvement of the methods of renewing pastures is under trial and will be continued.

Breeding.—(*a*) *Cattle.*—The improvement in the milk yield of the Montgomery herd by selective breeding will be continued.

(*b*) *Sheep.*—The breeding experiments are being continued. The value of the Merino rams as sires for crossing is being tested.

General.—It is expected that the remaining uncultivated arable area will be reclaimed this year.

REPORT OF THE IMPERIAL AGRICULTURAL CHEMIST

(J. WALTER LEATHER, V.D., PH.D., F.I.C.)

I.—ADMINISTRATION AND TOURS.

Charge.—This section was in the charge of myself during the whole year.

Establishment.—Mr. H. E. Annett, Supernumerary Agricultural Chemist, continued to officiate as Agricultural Chemist, Punjab, until November when he proceeded on one year and nineteen days' privilege leave and study leave, and has therefore been absent during the whole year.

Mr. Bhailal Motibhai Amin, third assistant, continued on deputation at the Sirseah Indigo Research Station until April 30th, when this station was closed and he rejoined his appointment in this section.

Mr. A. V. Iyer, fourth assistant, was appointed Assistant Agricultural Chemist, Bihar and Orissa, on 3rd November 1912. Mr. Lele was appointed in his place.

Babu Narendra Nath Mitra, M.Sc., an assistant, was appointed demonstrator in Chemistry at the Thomason Engineering College, Roorkee, on 2nd January 1913.

Babu Nirmal Chandra Bose, M.Sc., who was appointed in a temporary vacancy for three months, was appointed an assistant in the Bacteriological Section.

The vacancies which occurred during the year have been filled up by the appointments of Babus Phani Bhusan Sanyal, M.Sc., and Har Dyal Singh, B.Sc., as junior assistants.

It is naturally eminently satisfactory to find that there is such a constant demand for the services of assistants from this section, and this fact at the same time markedly assists recruitment, but on the other hand it means that of the establishment of eight assistants several are always merely under training and of no use for the general work

of the section, much less for research work. I desire to place on record my appreciation of the good services rendered by all, both the gazetted and non-gazetted officers, each of whom has evinced an exemplary interest in his special duty.

Tours.—The following tours were made by myself :—

1. July 1912. To Assam to advise the Scientific Officer of the Indian Tea Association regarding the fitting of the new laboratories.
2. August and November 1912. To Cawnpore and Orai in order to test a new method of determining soil moisture.
3. November 1912. To Marhowrah Sugar Factory to test a filter press.
4. February and March 1913. To conduct tests of sugarcane at the Parsa Factory.
5. March 1913. To the Muttra District to inspect the land included in the Nuh Jheel Project.
6. April 1913. To Cawnpore to test the effect of explosives on Usar land.
7. April to May 1913. To Peshawar to test sugar-beets.

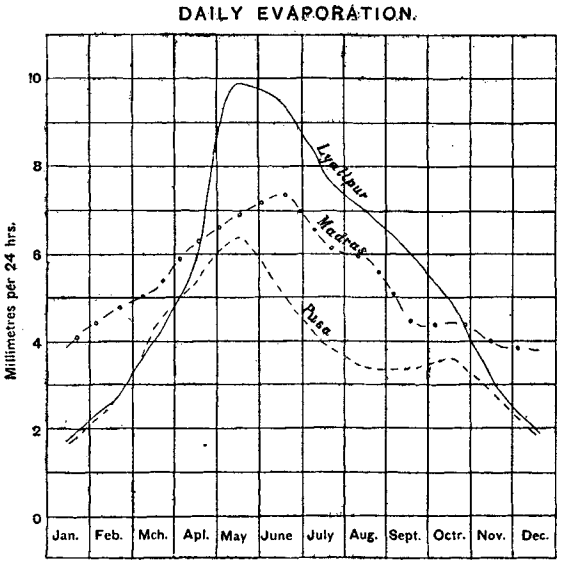
II.—Education.

Training.—Five students have been under instruction during the year. Of these one Government stipendiary and one private student resigned; one Government student was recalled for duty at the Agricultural College, Sabour, at the end of his first year's course, and the remaining two students are continuing their courses.

III.—Meteorology.

In addition to the usual data which are recorded daily on behalf of the Meteorological Department, records of (*a*) evaporation, (*b*) soil temperature, (*c*) drainage, and (*d*) pressure by means of a barograph have been maintained.

The records of *evaporation from a plain water surface*, after being maintained for about three years, were concluded during the past year because it seemed that no useful object would be served by more extended records. The data, together with others on the same subject, have been published as a Memoir. With the aid of these data, and others obtained at Lyallpur by the Irrigation Department, an empirical formula was deduced for the calculation of the evaporation at any place in India with the aid of the usual meteorological data. The accompanying chart illustrates



the quantity of water which becomes dissipated per day during the year at Pusa, Lyallpur and Madras. It rises to a much higher figure at Lyallpur during the hot weather than at Pusa or Madras, whilst during the cold weather the rate at Madras is higher than either of the other stations. The total water evaporated per annum is as follows :—

	cm.	ft.
Lyallpur	196	6·4
Pusa	126	4·1
Madras	193	6·3

These quantities are naturally much greater than what is lost from agricultural land. At Pusa the records show that from fallow soil the annual loss is (approximately) 28″, at Cawnpore 18″. Where crops are growing the quantities of water which are evaporated and transpired are somewhat greater[1] though the difference is not large.

The data regarding *soil temperatures* now extend over two years and they will be written up with a view to publication. They have shown that at Pusa, with a maximum hot weather temperature of, say, 110° F. (43° C.) the following maxima are realised in fallow soil :—

	°F.	°C.
1″ from surface	109	43·0
2″ from surface	106	41·0
3″ from surface	102	39·0
6″ from surface	97	36·0

The air temperature of many parts of India rises considerably above that of Bihar. In the Punjab maximum temperatures of 115° to 120° F. (46°—49° C.) are regularly registered for some weeks during the hot season and there the upper soil will naturally attain a correspondingly higher temperature than has been recorded at Pusa.

It has recently been shown[2] by Russell and Hutchinson that heating a soil to 122° F. (50° C.) occasions material biological changes of a beneficial nature, and that if a soil is heated for a sufficiently long time to 40° C. (104° F.) similar changes may occur.

Such soil temperature records therefore become of some practical importance. At the same time it must not be forgotten that not only is this subject a new one and at present very imperfectly understood, but also that in any case it is only the topmost 3″—4″ which are liable to such temperatures, whilst below this depth these biological changes are presumably either modified or non-existent. Also that the cultivating implements annually cause an

[1] *Memoirs, Department of Agriculture in India*, Chemical Series, Volume II, No. 2, pages 12—14.

[2] *Journal of Agricultural Science*, V, pages 152—220.

intermingling of these various layers or strata; so that conclusions regarding the biological effects of India's hot weather on the soil must be made very guardedly and not in the offhand manner that has been in some instances the case. It may be assumed as certain that "hot weather weathering," whilst valuable in some cases, will be undesirable in others.

IV.—Soil Problems.

The records of *drainage* which are obtained by means of the special gauges fully described in the Memoirs[1] have been continued. The nature of the crops grown was changed two years ago. On one gauge sann hemp, *Crotalaria juncea*, is grown during the monsoon and removed in September as near the end of the rains as may be without, however, leaving the land deficient in moisture, after which wheat is sown; on another gauge sann hemp is grown during the monsoon and allowed to ripen thoroughly when it is removed, and this soil then lies fallow. It is too early to draw any conclusions, but so far the wheat crop has not suffered from want of moisture, whilst the sann hemp on the second of these two gauges which is not alternated with another crop, already shows some signs of the deterioration which is so common where a leguminous crop is grown continuously on the same land. The object of the present system of cropping is to ascertain whether the marked deficiency of nitrate in the drainage water, which was noticed when the crops were wheat and maize, would be again experienced. (*Vide* Memoir, Volume II, No. 2, pages 31 *et seq.*)

Soil Moisture.—The investigations regarding the amounts of water present in Indian soils and the requirements of crops which have been carried out for some years by this section, showed the great necessity that exists for a rapid method of determining the amount of water in soils. The usual one of drying a weighed portion of soil in an oven is comparatively very time-absorbing, and

[1] *Memoirs, Department of Agriculture in India*, Chemical Series, Volume I, No. 5, and Volume II, No. 2.

consequently some attention has been paid to this question during the past three years. Hitherto, however, the object has not been successfully attained. Two new methods were tried during the past year, but neither was sufficiently accurate.

Water Requirements of Crops.—During the last monsoon season a series of pot-cultures were made in order to test the effect of different proportions of water in various soils on certain crops, namely, maize and cotton. It is of course well recognised that a too low proportion of moisture in a soil will prevent a full development of a plant, but the information available as to what is a too low proportion or a too high one for any particular soil and crop is extremely scanty, and practically non-existent for India. Moreover, as was to be expected, the effect of a low proportion in a particular soil varied with the crop. Whilst some interesting information was obtained by the pot-cultures, it seemed very doubtful whether this method is suitable for the proper solution of the enquiry; the work will probably have to be undertaken in the field.

Usar Soil.—In January I was requested by the Chief Engineer, Irrigation Branch, Public Works Department, United Provinces, to examine some land in the Muttra District which it has been proposed to bring under irrigation, and to report as to the probability of it becoming saline.

The tract is a section of *khadir* land on the Jumna, and the proposal includes the regulated admission of river water annually for irrigation purposes and its subsequent removal by drainage. Although the wells in the neighbourhood are frequently saline, the soil of this tract is generally very free from any contamination. Tests made on specimens which appeared likely to contain usar salts, showed that these consist of sulphate and chloride only, whilst the more harmful carbonate is absent. Moreover, the soil is very open and easily drained. There was no indication that if the project were carried through harmful results would follow.

The Use of Explosives in Agriculture.—For some short time past the use of dynamite or other similar explosive, for the breaking up of "hard pan" or the removal of tree stumps, has been recommended in the press. It is a subject which naturally lends itself to "copy," but should be approached with some little consideration. Experiments have been made at Cawnpore and at Pusa by myself in collaboration with the Chief Chemical Examiner, Ordnance Department, and the Deputy Director of Agriculture, Central Circle, United Provinces, and a separate report will be made. In any case these experiments will have to be considered preliminary, but it may here be suitably remarked that these explosives are comparatively expensive in India at present; also that, whilst it is possible to ascertain immediately to a limited extent what the nature of the effect of the explosive has been in any particular case, its agricultural value can only be subsequently ascertained by the growth of trees or crops on the land. Hence in any case it will only be possible to appraise correctly the financial aspect after the lapse of several years.

V.—Saltpetre.

After the failure which was referred to in last year's report, a test was made on a small scale with a filter-press. This press, which was borrowed locally, was not only small, but was imperfect in several of its parts. It was, however, sufficiently well repaired to test the probability of such a press being useful, and having shown considerable promise, a large sized one was ordered from Europe. This is expected to arrive shortly, and further experiments will then be made. In the meantime the salt "systems" which are involved, are being worked out by Babu Jatindra Nath Mukerjee, the assistant who is in charge of this work.

VI.—Sugar.

Date Palm Sugar.—Owing to Mr. Annett's absence no further work on this subject has been done, but the infor-

mation which he collected during the two preceding seasons was published during the current year as a Memoir.[1]

Cane Sugar.—As mentioned in my last report, tests had been made over two seasons of the experimental error which is involved when a "sample" of cane is taken from a field or plot of this crop. Dr. Walker, the Director General of Observatories, very kindly examined the results which I had obtained, and acting on suggestions which he made to me, a third series of tests were carried out during the past season. These resulted in more definite information and showed clearly what the probable error is when the sample is taken by certain methods. The matter has been put together for publication as a Memoir and is now in the press.

Sugar Beet.—Reference was made in my last annual report to the fact that some very good specimens of sugar beet had been grown at Peshawar by Mr. Robertson Brown, the Superintendent of Farms. This year I took apparatus to Peshawar and tested the fresh roots, which is naturally more satisfactory than testing them at Pusa after a long railway journey. A considerable number of individual roots were tested, as also average samples of 100 roots each from each field. A good deal of variation in size and quality was met with among individual roots, the percentage of sucrose varying from 9·0 to 20·0. The average samples tested 15·8 per cent. and 15·3 per cent. sucrose respectively, thus showing conclusively that this crop can be successfully cultivated in that part of India. The above percentage of sugar is materially better than some of the initial crops which were raised in San Francisco when the industry was first started there. I understand that the experiments will be extended considerably during the present year. There can be no doubt that this crop possesses great potentialities.

VII.—Milk.

Reference was made in last year's report to a series of tests, which was being made in conjunction with my col-

[1] *Memoirs, Department of Agriculture in India,* Chemical Series, Volume II, No. 6.

league Mr. Dobbs, of the quantity and composition of the milk of the Montgomery herd that is maintained here. The work was continued in the autumn and it is proposed to publish the records shortly.

VIII.—Programme of work for 1913-14.

Major subjects :—

1. Investigations of the availability of plant food in soils will be continued.

2. Experiments on possible improvements in the refining of saltpetre will be continued.

3. The variations of certain physical and chemical properties of individual seeds of the same plant are being examined.

4. The records of the amount and nature of drainage water from fallow land and from land under crops are maintained.

Minor subjects :—

5. An attempt is being made to ascertain the nature of the hydration of clay in soil.

6. The permeability of soils to water is being studied.

7. The relation of moisture in cereal grains to weevil attacks and the manner of absorption of certain insecticides is being examined in collaboration with the Imperial Entomologist.

Education.—This requires no special comment and will be conducted according to the lines laid down.

IX.—Publications.

The following have been published :—

1. The Date Sugar Industry in Bengal. H. E. Annett. *Mem. Dept. of Agri. in India*, Chem. Ser., Vol. II, No. 6.
2. Evaporation from a Plain Water Surface. J. Walter Leather. *Mem. Dept. of Agri. in India*, Chem. Ser., Vol. III, No. 1.

3. The Experimental Error in Sampling Sugarcane. J. Walter Leather. *Mem. Dept. of Agri. in India*, Chem. Ser., Vol. III, No. 4 (*in the press*).

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REPORT OF THE IMPERIAL ECONOMIC BOTANIST

(A. HOWARD, M.A., A.R.C.S., F.L.S.)

I.—TEACHING, TRAINING AND STAFF.

Charge.—I held charge of the section at Pusa during the year under review till April 28th, when I took six months' combined leave. The Second Assistant, Maulvi Abdur Rahman Khan, was placed in charge of the current work of the section at Pusa, and the Third Assistant, Munshi Ijaz Husain, was placed in charge at Quetta during my absence.

Students.—One advanced student from the Madras Agricultural College worked in the section from October 1st, 1912, to the end of April 1913. He has, I understand, since obtained an appointment at Coimbatore in the Provincial Agricultural Department.

Staff.—The work of the staff continues to be satisfactory. The Second Assistant has done excellent work at Pusa while the Third Assistant at Quetta has done well. The two fieldmen, Sarup Singh and Ram Pershad, and the clerk, Babu Ram Nechhawar Lal, worked well during the year.

II.—WHEAT INVESTIGATIONS.

The wheat investigations continue to extend and during the past year results of considerable value have been obtained.

Distribution of Pusa Wheats in India.

The growth of Pusa wheats in the various wheat-growing tracts of India has now emerged from the experimental stage and the distribution of seed is in progress on a large scale in Bihar, the United Provinces, Central Provinces and, to a limited extent, in the *barani* tracts of the Punjab.

Extensive seed farms for the growth of these wheats are now in working order and high grade seed, true to type, is being supplied in large quantities to the public.

The preliminary work relating to the improvement of the Indian wheat crop need only be referred to very briefly. One of the first practical results of the wheat investigations at Pusa was the demonstration of the fact that varieties with milling and baking qualities, similar to those of the best wheats on the English market, could be grown in Bihar under *barani* conditions. By the application of modern methods of selection and hybridization these high grain qualities were successfully combined with high yielding power, rust-resistance and strong straw so that wheats were found which gave, on land in fair cultivation, upwards of 2,500 lbs. of grain to the acre without irrigation. The milling and baking tests connected with this work were carried out in England by Mr. A. E. Humphries, a past President of the Incorporated Society of British and Irish Millers and a well-known authority on these questions. Mr. Humphries reported that the Pusa wheats were a great advance on those exported from India and behaved in the mill and bakehouse like Manitoba spring wheats, which are in greatest demand for bread making in England and which command the highest prices on the Home markets. At the same time enquiries were made in India itself as to the suitability of the new wheats as food for the people. In all cases both cultivators, landholders and the educated community preferred for their own food the Pusa wheats to those ordinarily grown in India.

The next step was to determine whether or not grain quality would be affected by growing these wheats in different localities in India and particularly under canal irrigation. In collaboration with Mr. Leake and with the assistance of a large number of officers of the Agricultural Department this work has been undertaken and the same wheat has been grown for several years at a large number of stations in the various wheat tracts and the samples have been tested by Mr. Humphries in England. The fact

has been demonstrated that wheats of first-rate quality can be grown under canal irrigation on the alluvium and also on the black cotton soils of Peninsular India.

During the past year the earlier results have received important confirmation. Pusa wheat grown in the Indus valley and on the black cotton soils has given better results in the mill and bakehouse than the same variety grown at Pusa. The general results are summed up in Mr. Humphries' last report as follows :—

"It has again been demonstrated that wheats of the highest class can be grown in India on several kinds of soil, and on land which has been irrigated. It has been shown that the high excellence of quality possessed by wheats grown at Pusa in previous seasons was not due to environment or agricultural practice, for the same varieties of wheat have yielded still better results elsewhere. It is interesting to note that this high excellence of quality was found existing in wheats indigenous to India, and that in the Pusa Nursery varieties, the progeny appear to possess intact the great strength of the strong parents. I have no doubt that any or all of the wheats tested will realize, some at once, some later, relatively higher prices on our markets than the existing Indian wheats of commerce. If these new varieties yield no more grain and straw per acre than those ordinarily grown, their extended distribution as seed is desirable; if, in addition, the new varieties will yield greater quantities of grain and straw than those ordinarily grown, the position of the Indian grower will be greatly improved, and the propagation of the new kinds should be pressed forward."

The most important feature of this last series of tests was the superiority, in the mill and bakehouse, of the samples of Pusa 12 from three stations in the Indus valley (Lyallpur, Mirpurkhas and Gurdaspur) over those grown in the Ganges valley. The significance of these results lies in the fact that high grain quality can be obtained in all the great wheat-growing tracts of India including the Punjab

and the black cotton soils of Peninsular India, both under dry and irrigated conditions. This is an important matter and one which must be considered in all schemes of wheat improvement. There is no longer any reason why (now that it has been shown that yield and quality can be combined in the same wheat) the distribution of poor quality wheats should be continued.

The attention of the wheat trade at Home has been drawn to the work in progress on the improvement of Indian wheat. A meeting was arranged this summer by Mr. Humphries at Weybridge with Mr. Petrie, the London Manager of Messrs. Ralli Brothers, when samples of Pusa 12, grown at the various stations in the Indo-Gangetic plain and on the black cotton soils of Peninsular India, were exhibited. The loaves obtained from this wheat were also shown side by side with those produced from the grade known as Choice White Karachi and No. 2 Northern (Manitoba). The loaves from Pusa 12 were almost identical with those from No. 2 Northern and were a great improvement on those obtained from Choice White Karachi flour. The opportunity was taken of obtaining Mr. Petrie's advice as to the best means of disposing of these wheats on the Home markets and of establishing the reputation of a grade of Indian wheat with superior quality. In addition, a sample of Pusa 4, grown on the Hathowrie Estate in Bihar in 1912-13, was exhibited at Mark Lane at a recent meeting of the Council of the Incorporated Association of British and Irish Millers where the wheat attracted a considerable amount of attention.

The present position of the cultivation of the Pusa wheats in the various wheat-growing tracts of India must now be considered. The work is being carried out by many officers of the Agricultural Department and the details given below have been obtained, partly from the publications and reports issued in the various provinces and partly by correspondence.

United Provinces.—The first experiments with Pusa wheats in these Provinces were made in the Botanical area

at Cawnpore by Mr. Leake, who showed for several years that fine samples could be grown under canal irrigation using far less water for the purpose than is ordinarily given to wheat. During the progress of this work at Cawnpore, the Allahabad Exhibition took place and at the Agricultural Conference which was held in connection with the Exhibition the Pusa wheats were shown. As a result, the Manager of the Court of Wards' Estates in the District of Kheri, Mr. Hoskins, became interested in the matter and some of the new wheats were grown successfully by his tenants in the season 1911-12. The results obtained from these various experiments led to a demand for seed. As the land available for wheat in the Botanical area at Cawnpore was not sufficient for seed-growing purposes, it was decided by Mr. Leake to utilize about 100 acres of the new farm at Kalai, near Aligarh, for the purpose of growing seed for distribution. The first crop was grown in the season 1912-13 and the yields of the various wheats over large areas are given below. Mr. Leake states that there was a failure of the canal and consequently some damage by white-ants, and that these facts must be considered in judging the outturns.

Yield of Pusa wheats at Kalai near Aligarh, 1912-13.

Name.	Yield in lbs. per acre.
Pusa 12	2,214
Pusa IX A 2	2,050
Pusa 101	2,010
Pusa 4	1,928
Pusa 110	1,846
Pusa IX E 9	1,702
Pusa 8	1,640

Trials were also carried out at the farms at Partabgarh and Benares where the following returns were obtained by Mr. Sharma, the Assistant Director of Agriculture :—

Yield of Pusa wheats at Partabgarh and Benares, 1912-13.

Name.	Yield in lbs. per acre.	
Pusa 12	2,020	Partabgarh.
Pusa 8	1,960	
Pusa 106	1,928	
Pusa 12	2,040	Benares.
Pusa 106	1,856	
Pusa 8	1,760	

The results obtained on the various Court of Wards' Estates were also successful, particularly on the Kheri estates. The season was not favourable to wheat, due to a prolonged drought and scarcity of irrigation water, followed by high winds and storms in February and March. Both Pusa 8 and Pusa 12 did well with the small amount of water the wells could supply, and being strong-strawed wheats stood up while the surrounding crops were laid by the storms.

The distribution of seed in this Province is being taken up energetically by the Agricultural Department. In the Central Circle, Mr. Burt, the Deputy Director, has issued seed for about 1,800 acres, largely to Co-operative Societies and Court of Wards' Estates. A large demand for seed has also arisen in the Eastern Circle as well as in the sub-montane tracts and a good deal of seed has been distributed in these areas. More, however, could have been distributed had seed been available, but in spite of a considerable amount being supplied by the seed farm at Dholi, near Pusa, the supply was not equal to the demand and the later indents could not be met. A large amount of seed, sufficient for all demands, should, however, be available in the Province next harvest.

Punjab.—During the past *rabi* season an extended trial of one of the Pusa wheats (No. 12) has been carried out by Mr. Southern, the Deputy Director of Agriculture, at the

Gurdaspur Experiment Station. The object of the trial was to compare the behaviour of this white wheat with high grain quality, with Punjab Type 13, a low grade red wheat which was found to be the best yielder of the local kinds. The trials were in duplicate on plots from two to three acres in area and the yields obtained are given in the following table :—

Trial of Pusa 12 and Punjab 13 at Gurdaspur, 1912-13.

Name.	Yield in lbs. per acre
Pusa 12	1,570
Punjab 13	1,161
Pusa 12	1,096
Punjab 13 . . .	1,084

The season was an unfavourable one for wheat. The monsoon ceased in August and no more rain fell before sowing time. After a single day's rain in November, there was a long drought, the Christmas rain failed and the crops were drying up when the storms of February and March improved matters. Hot winds in April, however, ripened off the crop too rapidly and the local variety was poor and shrivelled. Pusa 12, however, gave a very good uniform sample in spite of the unfavourable conditions and a good yield. This is the second time Pusa 12 has done well at Gurdaspur. Seed of this wheat is now being sold to zemindars in the *barani* tracts and it will be interesting to know their experience with this variety.

Pusa 12 has also been grown under canal irrigation by the tenants of the Lyallpur farm who obtained 1,744 lbs. of grain to the acre. The grain is of superior quality and it is probable that this wheat will do well when tried by the cultivators of the Chenab Colony.

Bihar.—The main lines of progress in Bihar during the past year relate to the organisation of seed farms and the supply to the public of well-grown seed, true to type, at a reasonable price.

In connection with the Bihar Planters' Association an arrangement has been made with Mr. Edward Danby to grow a large area of Pusa wheats on the Dholi and Bowarrah estates near Pusa so that a large amount of good seed will be available. This arrangement has been carried out successfully and about 600 acres of wheat were grown in the *rabi* season of 1912-13. Care was taken to rogue the plots, to keep the various kinds separate and to sell for seed only dressed grain of a high grade. The price charged was one rupee per maund above local bazaar rates and the whole seed supply was sold off at once immediately after harvest. Orders for upwards of 1,000 maunds could not be filled. These arrangements are being continued and during the present wheat season about 700 acres have been put down for seed wheat on these estates. The advantages of this method of seed supply are obvious. The expansion of the work is ensured at practically no cost to Government and the estates where the crop is grown to perfection for seed serve as useful demonstration areas to all interested in wheat growing. Further, the profits obtained by the estates should attract the attention of cultivators and zemindars to the advantages, to all concerned, which follow from a supply of good seed.

The returns obtained on this seed farm over large areas are given in the table below. The season was not favourable to wheat. Damage was done by abnormal heat after sowing time and also by a series of storms in February and March which laid the neighbouring crops. Most of the Pusa wheats, however, having good straw, stood well and in spite of the season gave good yields. Great advantage was obtained on this and other estates in Bihar by harrowing the young crops by means of lever harrows.

Yield of Pusa wheats at Dholi and Bowarrah, 1912-13.

Name.	Average yield in lbs. per acre.
Pusa 100	2,050
Pusa 4	1,846
Pusa 8	1,886
Pusa 12	1,640
Pusa 6	1,635

In addition to the seed farms near Pusa under the immediate control of the Imperial Economic Botanist, the distribution of these wheats has been taken up by the Bihar Agricultural Department and seed has been grown at Sabour, Dumraon and Bankipore. Seed for about 200 acres has been distributed by Mr. McGowan in the Bhagalpur Division while the successful trials of these wheats in the Patna Division will be continued. The yields obtained on the light lands of the Sabour farm are given below.

Yield of Pusa wheats at Sabour, 1912-13.

Name.	Yield in lbs. per acre.
Pusa 7	1,809
Pusa 12	1,664
Pusa 8	1,512
Pusa 106	1,087

Many of the indigo estates in Bihar are now taking up wheat growing and there is a considerable amount of local seed distribution in progress. It is impossible to obtain returns of these operations and to say what is the total area under wheat.

During the year two new Pusa wheats have been tried on estates in Bihar, namely, Nos. 4 and 6. The former is an early maturing wheat with strong straw which is very suitable for sowing with Java indigo. This wheat did well in 1912-13 and returns from 1,558 to 1,912 lbs. of seed to the acre were obtained on the various estates where it was grown. At Belsund factory Pusa 6 gave 1,640 lbs. of seed

to the acre which Mr. Reid considered very good for the year.

Central Provinces.—The results obtained in the Central Provinces at the Raipur and Tharsa farms by Mr. Clouston during the past year amply confirm the earlier successful trials of these wheats on the black soils which are referred to in detail in the annual report for 1911-12. A somewhat extraordinary result was obtained at Tharsa with Pusa No. 7 where the yield was 1,240 lbs. to the acre. As the outturn of the local kinds seldom exceeds 600 lbs. to the acre a yield of 1,240 lbs. to the acre is quite exceptional. The actual results of the growth of these wheats by the cultivators in the Eastern Circle have not yet been received as Mr. Clouston is on leave, but it is understood that they have been successful.

So far only one wheat, Pusa 4, has been tried at Hoshangabad. The results were satisfactory. This kind is also being tried at Jubbulpore by Mr. Evans who has this year asked for a further supply of seed.

The results of the recent milling and baking tests of Pusa wheats grown at Raipur, Tharsa and Hoshangabad are of considerable importance. The behaviour of these samples was somewhat better than that of the same wheats grown at Pusa and other stations in the Gangetic plain. As high grain quality is now shown to be possible on the black cotton soils of the Peninsula, a great improvement in the wheats grown can easily be accomplished.

Wheat Breeding.

Practically all the first set of improved wheats obtained at Pusa by selection and hybridization have been tried on the large scale in various tracts in India and the most suitable of these are now being grown for distribution on various seed farms. These wheats will be grown on, at Pusa, in pure culture, so that when necessary the seed farms can be re-stocked with a fresh supply of seed of any particular variety.

During the testing of these early selections and hybrids, considerable progress has been made in the work relating to a new set of crosses which promise to give still better results than the earlier ones. The object in view in this work has been to improve the best of the Pusa wheats in standing power, rust resistance and also in general hardiness. For this purpose crosses between Indian wheats, with good grain quality, and various English and American varieties were made in England in 1910 and two series of these hybrids are now in the fourth generation. This is by far the most promising material yet obtained at Pusa and it is more than probable that the strong straw, rust resistance and general vigour and hardiness of the English parent has been, as it were, introduced into Indian wheats. The fixation, isolation and testing of new wheats from these series is not likely to be a long process. Experience continues to confirm the paramount importance of standing power in any further progress in the improvement of the Indian wheat crop.

III.—Other Investigations.

Tobacco.—Substantial progress has been made during the year in the tobacco investigations at Pusa.

The only type of Indian tobacco found suitable for cigarettes in Bihar, when cured by the country method, is one known as Type 28. This was grown on a fairly large scale on the Dholi Estate during the last tobacco season and the crop was cured on the ground—an assistant being lent from Pusa to show the factory staff how to proceed. The yield of cured leaf to the acre was very satisfactory and the product was taken over by the Indian Leaf Tobacco Development Company at Dalsing Serai. This year a larger area is being grown on the Dholi Estate. The spread of the cultivation of this kind is now a matter of price. If the growers are able to obtain a premium for this kind from the Company to repay them for the extra care required in the curing process the area will expand. On the other hand, it must be remembered that there is no competition

on the part of the local trade for this tobacco when grown for cigarettes and at present the Company can to all intents and purposes make its own terms. This year a good deal of seed of this kind has been distributed not only to planters in Bihar, but also to Government farms in the Central Provinces and in the United Provinces.

Experience in tobacco growing in Bihar discloses the fact that every year the growers suffer a large amount of loss of crop and waste a good deal of labour. Both can be avoided. These losses are due to the primitive methods of growing the seedlings, to the frequent loss of the majority of the first sowings and to numerous casualties after transplanting, resulting in a very uneven crop. Experiments were made during the past year with a view to remedy this state of affairs. The seed beds were partially sterilized by making fires on the surface before sowing and also by heating the upper soil in pans. The results were exceedingly promising—the seedlings on the partially sterilized beds were much stronger than the rest and were ready for transplanting about a week before the others. These experiments are being extended and other methods of partial sterilization such as steaming are being tried.

A paper dealing with the results obtained on the inheritance of characters in this crop has been written by the Personal Assistant. This work is of interest from several aspects. It was undertaken with a view of obtaining some general idea of the best method of attacking the problem of the improvement of the quality of the Bihar tobaccos—more particularly from the cigarette tobacco standpoint. From the practical point of view the possibilities of obtaining better tobaccos by breeding have been shown to be certain, and several promising sorts have been isolated during the progress of the work. From the scientific aspect it has been shown that, provided proper precautions are taken, the inheritance of quantitative characters, such as those relating to the size and shape of a tobacco leaf, follows the Mendelian scheme. In this paper the results obtained on the inheritance of the factors concerned in the size and shape

of the leaf are new, and mark an advance in the application of modern methods of plant breeding to crops of economic importance.

Gram.—The selection experiments with gram referred to in the last annual report have been continued. The season was not very favourable to gram as the seed bed was too wet due to the storms of November followed by heavy rains at flowering time. The high yielding white gram, which in 1912 was valued at Rs. 5-8 per cwt. f. o. r. Bombay, again did well at Pusa and seed of this and of some of the other kinds is being tried in Bihar and also on various Government farms in the Central Provinces and in the United Provinces.

Fibres.—A good deal of work was done during the year on fibre plants, particularly with regard to the inheritance of characters in *Hibiscus Sabdariffa.* This is being continued and it is expected to publish the results obtained during the coming year.

In the case of *Hibiscus cannabinus* the promising kind, known as Type 3, has been grown for fibre with satisfactory results. Seed of this kind will be offered to the various Provincial Departments of Agriculture during the present year.

Methods of pollination.—Observations on the methods of pollination in the various crops grown at Pusa have been continued and an effort will be made next year to publish the results.

Indigo.—In consequence of the decision to close the Sirsiah Experiment Station, the work on indigo formerly carried out there was transferred to the Botanical Section at Pusa at the end of the last financial year. Six small tubes of selected indigo seed were received from Sirsiah and these have been sown at Pusa. In addition, a large number of indigo experiments were started at Pusa in October 1912 in continuation of those begun the year before. The indigo industry, which is now in a declining condition, presents three problems for immediate solution. In the first place, the best methods of growing Java indigo so as to avoid the

loss of plant during the late monsoon due to " wilt " have to be worked out at an experiment station and then tried on the large scale on estates. Secondly, the best way of growing good seed of this crop in Bihar has to be discovered. At present, the seed supply is erratic and often far below the demand. Lastly, the methods of pollination have to be investigated with a view to deciding whether or not there is any scientific basis for the idea that this crop will repay the application of modern methods of selection and breeding. Considerable progress has been made in this work, particularly on the successful treatment of " wilt " and some results of undoubted value have been obtained. If possible, a separate report will be submitted early in 1914 dealing with the position of the investigations to date.

In connection with the work on indigo some reference should be made to the relations which have arisen between the Botanical Section and the Bihar Planters' Association. Since the Tirhut Exhibition was held at Pusa in January 1912, two addresses have been given to the Planters' Association at Mozafferpore dealing with the various improvements in local agricultural practice discovered in the Botanical area at Pusa in the course of the plant breeding work. These addresses, which were given at the request of the President, were well received and were, during the present year, published in the form of a bulletin entitled *Some Aspects of the Agricultural Development of Bihar.* Particular attention has been drawn to the value of hot weather cultivation in Bihar, to the annual losses due to want of drainage combined with erosion by rain wash, to the value of green manuring with *sunn* on the higher well-drained lands and to the use of labour-saving devices in the shape of small cultivators, lever harrows and improved ploughs.

IV.—Work done in Europe.

While on leave in Europe during the present year a certain amount of work was accomplished relating to the investigations in progress at Pusa and Quetta.

Agricultural Exhibitions.—Two large Agricultural exhibitions were visited, namely, the Royal Agricultural Show at Bristol and the Agricultural Exhibition at Munich in connection with the ' Oktoberfest.'

At Bristol some attention was paid, at the request of the Government of India, to the Overseas section—a new departure at the Royal Show in which the assistance of India was requested. Government decided not to participate at present but to ask two of the officers of the Agricultural Department to submit a joint report on the nature and objects of this section of the Exhibition. Exhibits were sent not only by the Self-governing Dominions (Australia, Canada and South Africa), but also by some of the Local Governments of the Dominions (Victoria, South Australia, Queensland and Western Australia) and by various Crown Colonies (Federated Malay States, British West Indies and British Guiana) and Rhodesia. In addition, various Companies dealing with emigration sent large exhibits, such as the Orient Line, the Dominion Settlement Association, the Canadian Government Emigration Department, the Canadian Northern Railway and the Canadian Pacific Railway. India was represented by a small stall sent by the Department of Agriculture, Bengal. The feature of the Overseas section as a whole was the inducement held out to emigrants—labourers, small holders and farmers—to settle in the new countries. The exhibit of products was evidently a subsidiary matter and it was clear that the advantage to India of participating in such an Exhibition in the future would be almost negligible in proportion to the trouble and expense involved.

Some time was devoted both at Bristol and at Munich to the modern developments in the manufacture of agricultural implements which is not without interest to India at the present time now that the Co-operative movement is spreading and the purchasing power of the cultivator has been increased by union and is no longer limited by his individual resources. At Bristol particularly and to a less extent at Munich, the feature of the display of implements

was the attention that is now being paid to the design of chief machines of light draught suitable for small holdings. A large number of small firms are engaged in the business and as the tendency in Great Britain is all in favour of small holdings, it seems probable that among the implements designed several will be found of use under Indian conditions. There were also many designs of portable petrol engines of small power for agricultural purposes including several threshers driven in this manner. The contrast between the small handy implements exhibited at Bristol and the collection of heavy agricultural machines at the recent Allahabad Exhibition was most striking.

Fruit packing.—Some attention was paid to the progress in the methods of packing fruit which is going on in connection with the produce sent to the London market. Some new packing materials were observed which are said to be very successful. These will be tried during the next year at Quetta and if found useful under Indian conditions will be brought to the notice of those concerned. It is quite probable that the cost of the present packages used at Quetta can be materially reduced and work in this direction is already in progress.

Experiment Stations.—Visits were paid to the four leading experiment stations in Great Britain—Rothamsted, Merton, Cambridge and Long Ashton. Very important work is in progress at Rothamsted, particularly on the factors influencing the fertility of soils and on the accurate determination of the products of assimilation in leaves. The feature of the plant breeding station at Merton in addition to the great variety and interest of the problems in hand is the high standard of cultivation reached both in the green houses and also in the numerous plots outside. Everything was thriving and well grown and one left with the impression that Great Britain possesses at least one modern experiment station characterised by real vitality. At Cambridge some time was spent with Professor Biffen in going over the plant breeding work on wheat and other crops which is now being greatly extended. An area

of land is being taken up for plant breeding purposes only, where the new varieties can be grown on a moderately large scale before being issued to the farmers. At Long Ashton near Bristol, a visit was paid to the Fruit Experiment Station in connection with the National Fruit and Cider Institute where a good deal of useful and interesting work has been done.

At most of the experiment stations in Great Britain extensions are in progress due to the funds set free by the Development grant. There is a marked tendency to endow agricultural investigations, to make the work continuous and to render it independent of what may be described as irregular and precarious support. The progress of the work under the Development Commission cannot fail to be of interest to all concerned with the task of improving the rural economy of India.

Wheat.—The opportunity was taken of several consultations with Mr. Humphries relating to the work in hand on the improvement of Indian wheats and the testing of the resulting samples. Visits were also paid to Mark Lane and the Baltic and the most reliable advice available in London was obtained as to the best way of introducing the new Indian wheats to the trade and marketing them to the greatest advantage. In all these matters Mr. Humphries was invaluable and he spared no pains to help the work in every way.

Publications.—A memoir on the inheritance of characters in tobacco was passed through the press in England with a view of comparing the work done in Calcutta and London and the corresponding cost. The result was to show that printing and illustration work is both cheaper and better in London while the labour of passing a paper through the press there is materially reduced.

Drainage.—The opportunity was taken of examining the methods of drainage in use in northern and central Italy and the care taken in these tracts in freeing the arable land of excess water. The method adopted is identical in principle to that worked out in the Botanical area

at Pusa, but in some details the Italian practice is an advantage. Steps are being taken to improve the Pusa method. The progress that has taken place in Italian agriculture during the last fifteen years is remarkable not only in general cultivation, but also in the spread of the co-operative movement. In many respects the conditions in Italy are not dissimilar to those in India and might easily repay detailed investigation.

V.—The Development of the Fruit Industry of Baluchistan.

The present report deals briefly with the work accomplished up to September 1912 relating to the development of the fruit industry of Baluchistan and with the chief lines of progress which experience suggests should be taken up in the near feature. It will be convenient to deal with the matter under the following main heads :—

Fruit and Agricultural Experiment Station.

An area of 25 acres of land with two *shabanas* of water of the large Sirkhi *karez* has been acquired by the Local Administration for the purposes of a fruit and agricultural experiment station on the Sariab Road about two miles from Quetta. The purchase was completed at the end of August 1911 (with the exception of one of the *shabanas* which was bought in June 1912) and since that time the farm buildings, offices and boundary wall have been erected, a well sunk, and considerable progress has been made in the laying out of the area in large terraces to facilitate irrigation. Three artesian bores have been sunk which give a total flow of 1,500 gallons per hour. A fourth bore is being put down to the water-bearing gravel at the 150′ level. An experiment in pumping from one of these artesian bores by means of an oil engine is in progress and will, it is expected, be completed shortly. At the present time, bricked water channels are being laid down and various other permanent improvements are in progress. Four pairs of Sibi cattle

have been purchased and a supply of implements collected. Progress has been made in the enlistment and training of the staff.

While most of the year has been taken up with preliminary spade work in connection with the laying out and levelling of the land previous to planting in November 1912, nevertheless a few results have been obtained. These are as follows :—

1. *The raising of nursery stock.*—The usual practice in Quetta up to the present, both in the Government gardens and in those of zamindars, in the raising of new trees has been to side-bud on two or three years' old stocks, the time taken in raising budded trees being two or three years. This year it has been found that if the seedling stocks were ring-budded in May and June, strong plants can easily be raised ready for planting within a year of the sowing of the seed of the stock. This is an important matter from the point of view of the revenue of the station and also from the standpoint of a large supply of good trees for replacing the old fruit gardens and for new planting. The supply of good and abundant planting material for the Province will in future years be a simple matter.

2. *The saving of water.*—The most important direction in which the agriculture of Baluchistan can be improved is in the saving of water and in making the greatest possible use of the present supplies. Attention has therefore been paid to this matter and results of importance have been obtained. By means of surface cultivation after the winter rains, it has been found possible to conserve the moisture in the soil to a very considerable extent and this can easily be applied to the growth of wheat and fruit trees. It has already been taken advantage of in the raising of nursery stock and in the growth of tomatoes. The soil of the valley is also suitable for furrow irrigation so that there is every prospect that by means of this method of watering, combined with clean weeding and surface cultivation, the present water supply of the valley can be shown to be able to produce at least twice the crops grown at present.

3. *The use of green manure in Baluchistan.*—Closely bound up with the conservation of moisture by surface cultivation and improved methods of irrigation is the supply of organic matter to the soil so as to increase its water-holding capacity. The geological history of the Province suggests that the soil is likely to be deficient in organic matter. This is confirmed by the local agricultural practice in which large quantities of manure are employed. The easiest method of adding this organic matter would be to grow some leguminous plant on the winter rains and when irrigation water is available and to turn this into the ground in April and May. The best crop for the purpose appears to be clover (*shaftal*) and accordingly some of this was put down in the autumn of 1911. Two or three cuts were obtained, which were sold to the Military Dairy, and the next crop was ploughed in as a green manure. The soil was greatly improved and it is practically certain that this crop will prove of great value in the Province, as it will not only improve the tilth and fertility of the soil, but also increase its water-holding capacity. A good deal of work remains to be done to find out the best methods of utilising this crop to the greatest advantage in the rural economy of the Province.

4. *The arrangement of fruit gardens.*—At the present time there is little or no arrangement in the fruit gardens in the valley and there is no separation of the trees into early, mid-season and late so as to facilitate watering and picking. There is no order or method so that a vast amount of unnecessary work is done in gathering the fruit and a good deal of water is wasted, as it is almost impossible to water a few trees without irrigating the whole garden. To obviate this, a beginning has been made in the collection and propagation of the best local varieties which will be planted out systematically. A sufficient supply of trees has been raised this year and care has been taken to keep accurate nursery records. A few French trees have been imported and it has been arranged to introduce all the best kinds from the South of France next February so that

the experiment station will possess a wide range of kinds, many of which it is hoped will be useful for propagation. This collection will be of the greatest use in the future development of fruit-growing in Baluchistan.

The Renovation of a Neglected Fruit Garden.

At the request of the Hon'ble Colonel Ramsay, C.S.I., C.I.E., Agent to the Governor General in Baluchistan, the southern portion of the Quetta Residency compound—an area of about 14 acres—was taken up as an experiment in renovating and replanting a derelict and neglected fruit garden. The land was taken over in October 1911, but a supply of convict labour was not arranged for till July 1912 so that this portion of the work has been delayed to some extent. Progress, however, has been made and this garden is being cleared, graded and the land brought into cultivation. As much as possible will be sown with *shaftal* this autumn and some of the plots will be ready for planting in trees in November 1913, the trees, which are ready now, being grown on in the nursery till that date. Notwithstanding the bad state of this area when taken over, there is little doubt that it can be made to yield a good return provided the water supply from the Barnes and Tari *karezes* can be ensured and the present thefts of water prevented. The revenue of the year is expected to reach at least Rs. 1,000 which is more than the working expenses. This should increase considerably when the new trees come into bearing and till that time a large revenue should be obtained from *shaftal*.

During the present year two results of importance were obtained in this area :—

1. *Tomato cultivation.*—Except in the private garden of the Agency Surgeon (Colonel Duke), the cultivation of tomatoes does not appear to be understood in Quetta although the crop is easily grown. It was therefore decided to try an experiment on a large scale with tomatoes trained on the two-branch system of Colonel Duke combined with furrow irrigation, as is practised at Pusa in the case of

tobacco. A preliminary trial of this system was carried out at Pusa last cold weather, where it proved a great success. On repeating the experiment at Quetta, the assistant in charge failed to raise a proper supply of seedlings by the time I arrived in May, so that a miscellaneous collection of seedlings left over in the gardens of various vegetable-growers had to be collected and the best made of this very inferior planting material together with a small supply of plants raised by the Overseer of the Residency Garden. The plants, however, did better than was expected and up to the time of writing (September 19th) the income from an area of four-tenths of the acre has exceeded Rs. 600. About half of the fruit is not yet ripe and of this a good deal has already been destroyed by the early frosts. There is no doubt, however, that if the tomato seedlings are raised at Sibi and planted in good time for the whole crop to ripen before the cold weather sets in, the income from an acre of tomatoes (sold at Rs. 3 per maund) would result in a clear profit of Rs. 1,500 per acre at least. The amount of water required is small and the expenses of training and pruning are not very great. The experiment will be continued next year and will be conducted by Hira Lal, the Overseer of the Residency Garden. The experiment has greatly impressed the local growers, and has attracted a good deal of attention. Several vegetable-growers propose to take up this method of growing the crop next year.

2. *The transport of tomatoes.*—In order to test the demand for Quetta tomatoes in the Calcutta market, twelve crates of fruit have been exposed for sale in the shop connected with the Great Eastern Hotel. Packed in crates holding 24 chip baskets, each holding one seer, the fruit reached Calcutta in excellent condition and was sold at twelve annas per basket. This leaves a margin of profit of Rs. 12 per crate of 24 seers.

3. *The yellowing of peach trees in Quetta.*—In the Civil Station of Quetta, the peach trees have, as a rule, very yellow foliage, often accompanied by excessive gumming. Such trees are said to die very quickly and this experience has

been confirmed by the death of many trees this year which showed these symptoms markedly last year. Over-watering and want of cultivation do not appear to be the cause of the yellowing and there are no indications of insect or fungoid disease. The early symptoms appear to be identical with the mysterious disease in the Eastern United States known as "Peach yellows," but the later symptoms of "Yellows," namely, premature ripening and reddening of the fruit with very poor flavour, are not developed. The yellowing is therefore fortunately not due to "Peach yellows." The next point to settle was whether or not the yellowing is caused by unfavourable soil conditions. Evidence was obtained during the summer indicating that the yellowing is due to the soil and that green manuring with *shaftal* may prove to be the best remedy. The yellow condition does not appear to be propagated by buds taken from affected trees, as both these trees and trees with green, healthy foliage gave rise to budded plants which appeared equally healthy. Experiments are in progress to test these ideas still further and definite evidence on the subject should soon be forthcoming.

Packing Experiments.

During 1911, a considerable amount of attention was paid to the improvement of the present methods of packing fruit at Quetta with a view of making the most of the present railway transport to India. The results obtained were dealt with in detail in the progress report of 1911 and can be shortly recapitulated as follows :—

1. Returnable packages for long journeys in India are unsuitable on account of the cost of returning the empty boxes and on account of the frequent mistakes on the part of the Railway Company in charging the wrong rates.
2. All packages must be designed to prevent as far as possible thefts in transit by the railway servants. The frequent occurrence of these thefts is a great obstacle to the extension of the Quetta

fruit trade as the expense and trouble of sealing numerous small packages is very great. It should be possible, if the matter is strongly represented to the Railway Board, to fix the responsibility for the packages on certain individuals and to prevent cases of thefts in a manner which would not make it worth while to continue these malpractices.

3. Except for short distances, cheap non-returnable packages seemed to be the best, especially in the case of small consignments to private individuals.
4. The packages most likely to be useful at Quetta appeared to be (*a*) non-returnable peach crates with 3″ and 3½″ chip cubes for the five seer railway rate. (*b*) Grape boxes suitable for the 2½ and 5 seer rates. (*c*) Non-returnable and returnable crates holding 24 chip baskets, each holding about one seer, the whole coming under the 30 seer rate. (*d*) Cheap climax baskets for selling fruit at the markets and at the various gardens.
5. The best packing material appeared to be *sunn* fibre imported from Oudh in pressed bales. This was cheaper and better than cottonwool and also easier to handle than wood wool which also received an extended trial. Care must be taken to use only clean well-retted *sunn* for this purpose.

During the present year a supply of these packages likely to be of most use in Quetta was made to order by the British Basket Company of Glasgow and shipped to Karachi. They were placed on the market at Quetta and sold at prices sufficient to cover all expenses including that connected with their sale. All the packages were taken up by the Indian fruit traders and about half the supply imported was sold. In all about £45 worth was supplied to the trade. It is expected the rest will be disposed of

next year and that the expenses connected with the importation will be completely recovered.

Experiments on the transport of grapes were taken up on a small scale in 1912 and it was found possible to send these to Calcutta packed with *sunn* in the non-returnable crates. The prices realized were Rs. 2 per seer which gives a very good return. Unfortunately the supply of cork dust ordered for the grape packing experiments did not arrive in time, but it is hoped to carry out tests with this material later on.

As a result of the experiments of 1911 and 1912 it may be said that most of the fruit packing questions have been solved and that packages better and cheaper than anything to be produced locally have been brought to the notice of the trade. For a year or two it will be necessary for Government to finance the supply of these packages after which it will be best to get an agency established in Quetta and for the trade to supply itself. Mr. Bliss has agreed to take up the agency when the time comes.

Future Work.

As most of the initial difficulties connected with the scheme have now been overcome and a beginning has been made with the work, it is not out of place to indicate the lines of future progress and to sum up the present position. The prospects of success of the fruit scheme are exceedingly favourable and there appears to be no reason why the project should not fulfil the expectations of its promoters. As results accumulate and as the water-saving devices become known, there is no doubt that the lessons of the experiment station will be taken up at once. The present methods are haphazard and all that is done after the planting of the trees is to apply water in the most wasteful method that could be devised and take whatever crop happens to be produced. None of the zemindars realize the possibilities of the valley and there is no doubt that an area under fruit and other crops properly managed would revolutionise the present practices. What is possible in

the valley has been clearly indicated by the tomato experiment of this year and equally striking results are possible with other fruit crops. What is wanted is the application of scientific principles to crop production and the only way of doing this is for Government to continue to act as the pioneering agency and to show the way.

As regards the future the following are the chief lines of work which remain to be developed :—

1. *Propagation.*—More attention will be necessary in the raising of young trees for planting. A greater range of stocks is desirable and the trees should be trained while in the nursery. A large selection of kinds should be raised so as to prolong the season of each fruit and the losses to the Province in the past from the distribution of bad stock should be prevented in the future.

2. *Improvement in yield and quality.*—Great advances in the yield and quality of fruit are necessary before the industry can be developed. At present the yield of fruit per acre is very small and the quality is not good. Varieties which require good cultivation like peaches are very short-lived and the prevalence of the yellowing of the leaves indicates that these trees are not properly grown. Pruning is hardly understood at present and the trees carry only a small proportion of poor fruit compared with what is easily possible.

3. *Water conservation.*—The great need in agriculture in Baluchistan is the saving of water. In this connection the preliminary work which has been done on surface cultivation, furrow irrigation and the increasing of the water-holding capacity of the soil by green manuring should be developed and the possibilities of water-saving demonstrated by actual examples.

4. *Vegetable growing.*—Good vegetables can be grown at Quetta at a time when there are no supplies to be had in the plains. It has been demonstrated that tomatoes can be sent to Calcutta at a good profit and there is little doubt that this line of work can be extended considerably in the future.

5. *Fruit packing.*—The work on fruit packing should be continued, particularly with regard to grapes for which there is likely to be a great demand in India at good prices. Moreover, grapes grow well in Baluchistan and appeal to both Europeans and Indians in Hindustan. The importation of packages should be supervised for a year or two until the trade is in a position to supply itself. Possibly later on cool vans will be available for the Calcutta market and whole van-loads can be sent to that city.

6. *Collection of varieties.*—The work on the collection of the best indigenous varieties together with good kinds from France and the United States should be continued till the experiment station is really well stocked. The best of these trees should be propagated and the young trees made available to the public.

7. *Training.*—In addition to the purpose of the experiment station as a model for the Province it can easily be made use of as a training ground for *malis* and zemindars. The object aimed at should be to pass a number of men every year through the station and to train them in all branches of the work. In this way the standard of agriculture will gradually rise and fruit-growing will be placed on a higher plane. Detailed proposals on this subject are being submitted to the Local Administration.

VI.—Programme and Publications.

Programme of work for 1913-14.

1. *Training.*—The training of advanced students in this section will be continued.

2. *Plant breeding and plant improvement.*—During the year the following crops will be studied:—wheat, tobacco, oil-seeds, fibre plants and indigo.

(*a*) *Wheat.*—The production of improved and rust-resistant types by selection and hybridisation will be continued. The co-operative experiments on the influence of the environment on the milling and baking qualities of Indian

wheats, which are being conducted in collaboration with Mr. H. Martin Leake, Economic Botanist to the Government of the United Provinces, will be continued. The botanical survey of the wheats of Baluchistan and the agricultural survey of the wheats of Bihar, will be completed.

(*b*) *Tobacco.*—The production of new varieties by selection and hybridisation will be continued, as well as the testing and curing of the varieties already isolated. The detailed study of the inheritance of characters in tobacco is being continued by the Personal Assistant.

(*c*) *Oil-seeds.*—The study of the oil-seeds of India will be continued on similar lines to those adopted in the investigations on wheat.

(*d*) *Fibres.*—The isolation and testing of pure races of the fibre plants of India will be continued. The study of the inheritance of characters in these crops is being continued.

(*e*) *Fruit.*—The fruit experiment at Pusa will be continued on the lines laid down in the first Fruit Report. During the months May to September the work connected with the development of the fruit industry of Baluchistan will be continued.

Publications.

Some progress was made in the publication of results and a certain number of completed pieces of work were written up during the year. A good deal, however, remains to be done to bring the publication of results up to date.

The following papers were written or published during the year :—

1. Some Aspects of the Agricultural Development of Bihar. *Bulletin No. 33, Agricultural Research Institute, Pusa.*
2. The cultivation and transport of tomatoes in India (with G. L. C. Howard). *Bulletin No. 1, Fruit Experiment*

Station, Quetta. (Reprinted in the *Agricultural Journal of India,* Vol. VIII, Part III.)

3. Some improvements in the packing and transport of fruit in India (with G. L. C. Howard). *Bulletin No. 2, Fruit Experiment Station, Quetta.* (Reprinted in the *Agricultural Journal of India,* Vol. VIII, Part III.)
4. The improvement of crops (with G. L. C. Howard). *Agricultural Journal of India,* Vol. VIII, Part II.
5. Yield and quality in wheat (with H. Martin Leake and G. L. C. Howard). *Agricultural Journal of India,* Vol. VIII, Part II.
6. Natural root-grafting. *Agricultural Journal of India,* Vol. VIII, Part II.
7. The improvement of Indian wheat—a paper read at the Punjab Agricultural Conference, Lyallpur, November 4th, 1912 (with G. L. C. Howard). *Agricultural Journal of India,* Vol. VIII, Part I.
8. Sesam, *Sesamum indicum,* L. *Die Züchtung der landwirtschaftlichen Kulturpflanzen,* Bd. V, Paul Parey, Berlin, 1912.
9. Deccan-order Ambari-Hanf (*Hibiscus cannabinus,* L.). *Die Züchtung der landwirtschaftlichen Kulturpflanzen,* Bd. V, Paul Parey, Berlin, 1912.
10. Hibiscus Sabdariffa, L. *Die Züchtung der landwirtschaftlichen Kulturpflanzen,* Bd. V, Paul Parey, Berlin, 1912.
11. Indischer Sunn-Hanf (*Crotalaria juncea,* L.). *Die Züchtung der landwirtschaftlichen Kulturpflanzen,* Bd. V, Paul Parey, Berlin, 1912.
12. Kugelfruchtige Jute (*Corchorus capsularis,* L.). *Die Züchtung der landwirtschaftlichen Kulturpflanzen,* Bd. V, Paul Parey, Berlin, 1912.
13. Langfruchtige Jute (*Corchorus olitorius,* L.). *Die Züchtung der landwirtschaftlichen Kulturpflanzen,* Bd. V, Paul Parey, Berlin, 1912.
14. Studies in Indian Tobaccos. No. 3. The inheritance of characters in *Nicotiana tabacum,* L. (G. L. C. Howard). *Memoirs Department of Agriculture in India* (Botanical Series), Vol. VI, No. 3.
15. On the inheritance of some characters in wheat—I (with G. L. C. Howard). *Memoirs Department of Agriculture in India* (Botanical Series), Vol. V, No. 1.

REPORT OF THE IMPERIAL MYCOLOGIST

(E. J. BUTLER, M.B., F.L.S.)

I.—CHARGE AND ESTABLISHMENT.

I was on privilege leave for the first six days of the year, since when I have remained in charge of the section. Mr. F. J. F. Shaw continued to hold the post of Supernumerary Mycologist until April 21st, when he left to take up his acting appointment as Government Mycologist, Madras. He was confirmed in the service during the year. Mr. J. H. Mitter, Second Assistant, officiated as Assistant Professor of Botany in the Agricultural College, Lyallpur, until the end of August when he was appointed Assistant Professor of Botany, Muir Central College, Allahabad. The vacancy thus caused was filled by promotion in order of seniority, S. Pasupati Iyer coming in as Second Clerk. All the staff have worked well.

II.—TRAINING.

Babu K. C. Banerji, B.A., L.Ag. (Nagpur), a stipendiary student from the Agricultural Department, Bihar and Orissa, was under training until August 17th.

III.—DISEASES OF PLANTS.

The investigation of diseases of plants caused by fungi, and the more routine work of dealing with enquiries regarding the identity and treatment of crop diseases, formed, as usual, the greater part of the work of the section.

(1) *Rice diseases.*—The disease of this crop in Eastern Bengal, locally known as *ufra*, has assumed serious proportions. The districts known to be affected are Noakhali, Tippera and Dacca. In these districts paddy is the staple food crop, occupying over 70 per cent. of the cultivated area or some $2\frac{1}{2}$ to 3 million acres, with an outturn of about

1,100,000 tons of clean rice. Both the main winter crop, or "aman," paddy and the autumn, or "aus," crop suffer, but the damage is much greater in the former, as its long growth period allows of a progressive increase of the parasite. The most severely attacked varieties are those grown in the lower lands, subject to early inundation and where transplantation is not possible. A large part of the rice grown is of this class; the transplanted varieties, grown on higher land, occupy a smaller area and do not seem to get the disease. The lower land is under water for a considerable period every year and gets little cultivation, being often allowed to remain covered with weeds and stubble after harvest until the first spring showers. The organism, an eelworm of the genus *Tylenchus*, mentioned in last year's report as the suspected cause of the disease, has been found during the year to be constantly present in every case and attempts to induce the disease experimentally by inoculating healthy paddy with it have been fully successful both at Pusa and at Dacca. The worm is one previously undescribed and, up to the present, has been found only on paddy suffering from *ufra*, or in the stubble from the diseased crop. On the living plant it is active, feeding and reproducing freely; after the death of the plant it assumes a passive condition, lying coiled up within the sheaths and glumes, and in this state can remain alive, if kept dry, for many months. Activity is resumed, at Pusa, about April. The length of the life cycle is not yet known, but there are several generations during the growth period of the crop and the rate of multiplication appears to be very considerable.

Experiments have been undertaken, in collaboration with the Bengal Department of Agriculture, to devise methods of fighting this disease. Paddy probably suffers less than any other cereal from epidemic diseases and every effort will have to be made to check the spread of *ufra*. The losses caused by it are very great; in some cases the crop is not worth harvesting, in many others it is reduced to half or a quarter of the normal. In the districts referred

to nothing else can replace paddy as a food crop, and in certain parts the distress that has been caused is undoubtedly very great. The most hopeful method of attack appears to be the destruction, by burning, of the stubble from diseased fields, and the Bengal Department has arranged to expend a considerable sum in experiments in this direction. A small area has been selected near Comilla for further experiments, especially in cultivation and trial of varieties. The enquiry will be treated as the most important on which this section is engaged, and efforts will be made in particular to fill up the gaps in our knowledge of the life history of the parasite. An account of the work up to date has been included in a Bulletin on rice diseases, now in the press, and a less technical paper has been contributed to the Agricultural Journal.

Amongst other diseases of rice investigated during the year, "bunt" (caused by *Tilletia horrida* Tak.) was found to be widely prevalent in Burma, though usually in such small amount as to cause little loss. Its detection was the result of complaints received from Germany, of the presence of black spores in rice meal imported from Rangoon and Moulmein. The disease is one which may well increase in virulence as time goes on and it is useful to know that we have a safe and assured preventative in a seed steep, similar to one employed against the allied wheat bunt.

The false smut of rice [caused by *Ustilaginoidea virens* (Cke.) Tak.] was found to occur throughout a large part of the rice-growing tracts of India. It does rather more damage than bunt, but still not enough, usually, to repay treatment. This is fortunate, for no treatment is known, and experiments to follow out the life history of the fungus and ascertain how it infects the host plant have failed. These experiments will be continued as opportunity offers.

Probably more important than either of the two last mentioned diseases is that caused by *Sclerotium Oryzæ* Catt., which I found in Burma and Madras and which also occurs at Pusa. Its symptoms are obscure and it can

easily be overlooked, as its chief effects are to cause excessive late tillering of the plant and partial sterility of the ear. Its further investigation was taken up by Mr. Shaw, who has established the parasitism of the fungus and studied its behaviour in artificial culture. The disease is probably one of the causes of the condition known in Burma as *gwa-bo*, in which an undue proportion of the ears are light or partially sterile and which is said to represent a very great aggregate loss. I found on local examination that most of the loss was attributable to insect pests, chiefly borers, and that fungus injury was probably too slight to be of economic significance. Mr. Shaw has prepared an account of his investigation, which is in the press as a Memoir.

(2) *Sugarcane diseases.*—The " red rot " of sugarcane (caused by *Colletotrichum falcatum* Went.), which is the worst fungus disease of this crop in India, has been under study at Pusa for a number of years. Various difficulties which were met with have delayed the writing up of the results, but sufficient information has now been obtained to justify publication. A Memoir, prepared jointly by myself and A. Hafiz Khan, Third Assistant, to contain the results of experimental work since 1906, has been submitted for publication. The experiments have been chiefly directed to obtain information as regards methods of infection. It has been securely established that the most common method in Northern India is by the planting of infected setts from a previously diseased crop, a method that has been recently controverted in Louisiana and the West Indies. The failure of sett selection which has been observed on several occasions, has been shown to be due to the presence, in severely diseased crops, of a percentage of infected canes which do not show the characteristic warning symptom of reddening in the pith. In attacks of ordinary severity this percentage is negligible, but in severe epidemics it is advisable to avoid the use of any cane from the diseased crop for seed. It has been further shown that sound setts may be infected after planting, though in

Northern India the parasite appears to die out rapidly in the soil and there is not much danger from this source, unless there is carelessness in allowing rotten canes to lie on the fields after harvest. Infection by air-borne spores through wounds in the stem, such as those caused by boring insects, was found to be uncommon, though accepted as the usual method in most other countries where the disease is prevalent. The leaf scars at the joints, left after the leaves are removed in stripping or wrapping the cane, are stated by some observers to admit the parasite, but it was found that this did not occur if the leaf had reached maturity and came away readily. On the other hand the shoot and root eyes at the joints can be infected and through the latter, especially, the fungus has no difficulty in gaining an entry into the cane pith. The most probable origin of the infective matter was found to be a form of the fungus which is parasitic on the midrib of the leaf, and which had been overlooked by most observers.

From these results, backed by field observations, it is concluded that the most important precaution to be taken against the disease is to select the setts used for planting, so that only those with unreddened pith are used. The effect of sett selection in keeping the disease from reaching epidemic severity has been very satisfactory in several Bihar estates and elsewhere, and it should be made a routine practice. In very severe attacks sett selection may fail, and it may be necessary to introduce new seed from outside. Care must be taken at the same time to remove early cases of the disease, in order to avoid risk of infection through the shoot and root eyes, and also to destroy rotten canes and trash after harvest, so as to prevent infection of the setts at or after the time of planting. Finally it is pointed out that the " thin " canes, in which India is so rich, are almost immune to the disease; that the comparatively little damage caused by red rot in Java may be due to the fact that many of the best Java canes are the progeny of crosses between Indian thin canes and the locally grown thick kinds; and that there is every

reason to hope that similar results can be obtained in India by hybridization.

Three minor sugarcane diseases, caused by undescribed species of fungi, have also been under study, and the work was advanced sufficiently by the end of the year to allow of the results being written up. One of these, occurring at Samalkota and Jorhat, is possibly that referred to in last year's report as resembling *sereh*. They will be more fully dealt with in the next report.

Phytophthora investigations.

Mr. J. F. Dastur, First Assistant, completed his investigations of a new species of this destructive genus, which was found attacking castor, and published a detailed description of it in the Memoirs. The parasite causes the most injurious fungal disease of this crop known, and is especially harmful to eri-silk worm breeders. On seedling plants it causes a " damping off," which may affect 30 to 40 per cent. of the seedlings; older plants are attacked chiefly in the leaves. A full account of the morphology of the parasite is given, the chief interest centring in the discovery of a new type of reproduction. Shortly before the publication of the paper, this discovery was anticipated by a British Mycologist, working with an allied species. The growth of the fungus in artificial culture was successfully attempted. A very complete series of inoculation experiments was carried out, potato, tomato, brinjal, *til* and several other plants proving susceptible to attack.

The study of *Colocasia* blight (caused by *Phytophthora Colocasiæ* Rac.) was commenced by Mr. G. S. Kulkarni, Mycological Assistant of the Bombay Department, when a student at Pusa in 1909, and completed by myself during the year. We published a joint account of it in the Memoirs, giving details of the characters of the disease and the morphology and biology of the fungus. The intensity of the attack is closely dependent on the character of the monsoon, being worst in wet years. In addition to the already known damage caused by rotting the leaves, the

parasite was found to infect the corms and to cause considerable injury after the crop is lifted. Pure cultures were grown in 1912, and a large series of inoculation experiments carried out, but the species is much more restricted in its choice of hosts than the castor parasite.

A serious outbreak of potato blight (caused by *Phytophthora infestans* de Bary) occurred in the Gangetic Plain, where the disease has not been reported since 1902. The outbreak is probably to be attributed to the fact that the local seed supply failed, in a great measure as a result of damage caused by the potato moth. A large import of hill seed occurred at the beginning of the cold weather and no doubt introduced the fungus, which is endemic in the hills. Mr. Dastur has obtained pure cultures of the parasite and is testing its temperature relations, as this appears to be likely to prove the most important factor in its control.

Rhizoctonia.

The results of Mr. Shaw's work on this genus of soil-dwelling parasites, referred to more fully in last year's report, were published during the year. He has continued his investigations, particularly with forms parasitic on lucerne and Delphinium. It is evident that great confusion of species exists in the published literature of the genus and his researches should do much to clear this up. It is of interest to record that a severe attack of opium poppy blight, which has generally been supposed to be caused by *Peronospora arborescens*, was found to be due last season to *Rhizoctonia*. It is hoped that Mr. Shaw will be able to continue his work on this, after his return from Madras.

Wheat rust.

Wheat rust was prevalent in Bihar last season and some interesting observations were made in selected areas at Pusa, on the influence of soil moisture and density of growth on the disease. Orange rust (*Puccinia triticina*)

appeared early and spread uniformly, without much relation to position in the field or density of the crop. Later on it became more intense where the crop was heaviest and tallest, but was soon masked by yellow rust (*Puccinia glumarum*). This did not appear in any quantity until the crop was nearly full grown but then developed with great intensity wherever the crop was tall and dense. Black rust (*Puccinia graminis*) was late in appearing and did not show any regularity in distribution. In February and March, Dr. Leather kindly made some determinations of soil moisture and air humidity in two plots, one with a light, thin crop where rust was slight, and the other where the crop was heavy and rust severe. The soil moisture was much better in the latter, especially from the 3rd to the 6th foot in depth. The humidity was taken within the crop, about 4 inches above ground level, the first test, lasting for 7 to 8 hours, being made on February 14th, in dull and humid weather. In the thin crop the relative humidity was 57·3 per cent. and the mean air temperature was 26° C. In the heavy, badly rusted crop, the relative humidity was 76·7 per cent. and the mean air temperature 23° C. A second test was made on February 21st, the crop having been much laid by a storm on the 15th and the day being fine with a dry west wind blowing. No appreciable difference was found in the two plots.

The intensity of the attack of yellow rust and the later stages of orange rust thus varied directly with the soil moisture and the air humidity within the crop. The early stages of orange rust would not be exposed to the influence of the latter factor, as at that period the crop is too small to cover the ground closely. By the time black rust appears, transpiration has much diminished, as the crop is then almost ripe; the air temperature is higher and the drying west winds have usually set in. Hence the late rust is not much exposed to differences in air humidity. Of the two factors the immediately important one is apparently the humidity of the air within the crop, but

this again is connected with the soil moisture, as it must depend largely on the density of the crop and the vigour of transpiration.

Ground-nut diseases.

The cultivation of ground-nut in the Bombay Presidency underwent a progressive decline between 1895 and 1903. This decline was attributed in 1902 by Mr. Mollison, then Inspector General of Agriculture, to the extension of disease in the crop. In that year I found a fungal disease (caused by *Septoglœum Arachidis* Rac.) was doing great damage. Attempts to check it by spraying failed, and the only hope seemed to lie in the introduction of early maturing and resistant varieties. Recently the cultivation of ground-nut has again expanded and various reports led me to believe that this disease had diminished. On visiting the Presidency I found that this was the case to such a degree, that I had considerable difficulty in finding any attacked plants. Coincident with the decline of the disease there has been a change in the varieties of ground-nut grown. The Bombay Department of Agriculture introduced a number of foreign varieties in 1901 and the following years, and these have almost replaced the old varieties, except in the Poona District. It is difficult to avoid the conclusion that the introduction of the new varieties is connected in some way with the decline of the disease, though a direct connection is hard to establish, since the old varieties, still grown near Poona, are now equally free from attack. It would, however, be interesting to know how far natural crossing has occurred between the new and the old varieties, as in this there is a possible explanation of the difficulty. I think that Mr. Mollison and the Bombay Department are entitled to claim the credit of having successfully fought one of the worst diseases of cultivated crops which I have seen in India. The area under ground-nut in the Deccan rose from 56,000 acres in 1902-03, to nearly 200,000 acres in 1911-12.

Cotton and Sesamum wilts.

A wilt disease of cotton (caused by *Fusarium vasinfectum* Atk.) is probably the worst fungal disease of this crop in the United States and has been reported from most other cotton-growing countries. It has been known for some years that a similar disease occurs in the Central Provinces. Sesamum is also attacked by an allied disease, and an attempt was made to isolate the parasites concerned, establish their identity and make as complete a study of the diseases as possible. I found cotton wilt extends over a large area from the Central Provinces to Belgaum, being especially prevalent in the Berars, where it has been carefully observed by Mr. Clouston. Sesamum wilt extends from Hoshangabad, where Mr. Evans gave me much useful information regarding its distribution and field characters, into parts of Bombay. Fungi of the genus *Fusarium* were isolated from both crops and have been maintained in pure culture. The first attempts to test their parasitism failed, possibly because the season was already too far advanced, and the work is, consequently, being repeated.

Anthracnose of Sisal hemp.

This disease was investigated by Mr. Shaw, who established the parasitism of the fungus (*Colletotrichum Agaves* Cav.) previously suspected to be its cause. It was found to infect species of *Agave* readily and to produce a characteristic leaf disease. An account of the work was published in the Agricultural Journal of India, January 1913. Collecting and burning diseased leaves, and spraying with Bordeaux mixture, are measures which are recommended as likely to prove efficacious in checking the disease.

Indigo disease.

The work mentioned in last year's report was continued, but led to no useful results. Neither Mr. Shaw nor myself, working independently, was able to obtain any evidence that the so-called disease is caused by any definite parasite. Some half a dozen species of fungi were isolated from

plants in various stages of "disease," but none of these proved capable of reproducing it. As they were mostly belonging to the class of weak parasites, capable of infecting the host plant only when the latter has been weakened by some other agency, it was concluded that the cause of the trouble lies deeper. Since it is practically certain that it is not mycological, the enquiry was abandoned, and a note giving a summary of the work, and the reasons for this step, was submitted to the Bihar Planters' Association, and circulated amongst the members.

Forest tree diseases.

This section, as usual, assisted the Forest Department in examining and reporting on specimens of fungus diseases of forest trees, mostly received through the Imperial Forest Botanist. As this is rather a specialised branch of mycology and as the work of the section has grown too much to allow of all enquiries being dealt with equally fully, arrangements were made with the Forest Botanist, defining what assistance we were prepared to give. Under present circumstances, it will not usually be possible to undertake any definite research into the causes of undescribed diseases of trees, but where the parasite is already known, or is allied to known ones, assistance can be given. The Forest Botanist was supplied with all the information available in this section on the obscure "spike" disease of sandal.

Green parasites.

Mr. Shaw continued his investigation of the flowering plant *Striga*, which is parasitic on the roots of jowar, sugarcane and other *Gramineæ* in India. He also took up the study of an allied plant, *Sopubia*, which attacks several cereals. When the work was commenced, little was known regarding these interesting plants, but the result of work on South African species of *Striga* has recently been published. It is still necessary to compare the Indian species

with those of South Africa and the investigation of *Sopubia*, about which nothing whatever is known, is equally important. The economic aspect has not, as yet, been considered in South Africa, and this side of the enquiry is of primary interest to us.

Other plant diseases.

The section has, as usual, been consulted by the Scientific Department of the Indian Tea Association on several occasions. It was also consulted by the Australian Prickly Pear Commission, on the diseases of that plant in India, and by the Agricultural Department of British East Africa, on coffee leaf disease. A serious disease of betle pepper, which causes great loss in certain parts of India, is being investigated and appears to be caused by an undescribed species of *Colletotrichum*, of which the perfect stage has been obtained in culture. Experiments in checking anthracnose of plantains were continued. The treatment of oat smut by formalin steeping was successfully demonstrated on several estates in Bihar, and is being taken up satisfactorily. Work with *Pennisetum* smut was continued, but the life history of the fungus has not yet been worked out. A disease of maize, hitherto unknown outside Java, appeared at Pusa last year. It is exceedingly destructive in Java, but our knowledge of the life history of the parasite [*Sclerospora Maydis* (Rac.) Butl.] is imperfect and an attempt was made, and is being continued, to obtain fuller information on this point. An account of it was published in the Memoirs. The "damping off" of seedlings (caused by *Pythium de Baryanum* Hesse) was found for the first time in India last year, though common in temperate climates. Its study in culture was undertaken, and an account of it published in the Memoirs. The rotting of stored potatoes is being investigated at the instance of the Economic Botanist, Bihar and Orissa; much of the loss has been found to be due to *Rhizoctonia*,

IV.—Systematic Work.

The additions to the herbarium continued steadily, the total number of mounted sheets added being 780. Most of these were Indian, the most important outside contributions being from Berlin and Manilla. A considerable number of parasitic fungi were named for the college collections of the Provincial Departments of Agriculture, for other colleges, and for the Forest Research Institute. Large collections of Indian fungi were distributed to interested persons. The *Hypocreaceæ* of our collections were kindly named by Mr. T. Petch, Government Mycologist, Ceylon. The perfect stages of the rusts of sugarcane, cotton and fig were discovered during the year and will be described shortly. Mr. Shaw has commenced the systematic study of some soil fungi.

V.—Programme of work for 1913-14.

(1) *Research and experimental work.*—The continued investigation of the disease of paddy, known as *ufra* in Bengal, will be regarded as the most important individual item of the work of the section. Other diseases of paddy will be studied as occasion arises.

Of sugarcane diseases, the study of which will be continued, the most important in view is the *sereh*-like disease at Jorhat and elsewhere. It is hoped to ascertain definitely whether it is caused by a fungus, and, if so, whether it is identical with a new disease of which an account will shortly be published.

The wilt diseases of cotton and sesamum are major diseases, the investigation of which will be continued.

The work on potato blight may also require to be treated as an investigation of importance, if the disease again recurs, and the same applies to the opium poppy blight, referred to in the body of the report.

Besides the investigation of the last-mentioned disease, Mr. Shaw may be able, on his return from Madras, to progress with his sutdy of some green parasites, of which

a more precise knowledge than is at present available is greatly required. His work on soil fungi is likely to extend over a considerable period and is not of such immediate importance as the other enquiries, but it probably has a bearing on such questions as the decomposition of green manures, and may give valuable results.

Minor investigations are those of the anthracnoses of plantain and betle pepper, smut of *Pennisetum*, maize mildew and further work on diseases of castor.

(2) *Training.*—This will be continued on the lines indicated in the Prospectus. Short courses will also be given if any students of the Institute wish to attend.

(3) The routine work of advising on plant diseases will be continued and assistance will be given as usual to the Provincial Departments of Agriculture, the Forest Department, Planters' Associations and the general public.

(4) It is hoped to make further progress with the publication of descriptive lists of Indian fungi, and, if time permits, the preparation of a 5th part of "Fungi Indiæ Orientalis" will be taken up. This will be the most important item of the systematic work.

VI.—Publications.

1. Preliminary Report on Ufra disease of Rice in Noakhali District, E. J. Butler. *Bull. of the Bureau of Agricultural Intelligence and of Plant-diseases*, 3rd year, No. 7, July, 1912, p. 1661.

2. The Morphology and Parasitism of *Rhizoctonia*, F. J. F. Shaw. *Mem. Dept. of Agri.*, Bot. Ser., IV, No. 6, September, 1912.

3. Anthracnose of Sisal Hemp, F. J. F. Shaw. *Agri. Journ. of India*, VIII, No. 1, January, 1913.

4. Report on Mycology for 1911-12, E. J. Butler. *Annual Report of the Board of Scientific Advice*, April, 1913.

5. On *Phytophthora parasitica* nov. spec., a new disease of the Castor oil plant, J. F. Dastur. *Mem. Dept. of Agri., India*, Bot. Ser., V, No. 4, May, 1913.

6. Colocasia blight, caused by *Phytophthora Colocasiæ* Rac., E. J. Butler and G. S. Kulkarni. *Mem. Dept. of Agri., India*, Bot. Ser., V, No. 5, May, 1913.
7. *Pythium de Baryanum* Hesse, E. J. Butler. *Mem. Dept. of Agri., India*, Bot. Ser., V, No. 5, May, 1913.
8. The Downy Mildew of Maize [*Sclerospora Maydis* (Rac.) Butl.], E. J. Butler. *Mem. Dept. of Agri., India*, Bot. Ser., V, No. 5, May, 1913.
9. Diseases of Rice, E. J. Butler. *Bull. 34, Agri. Res. Inst., Pusa* (*in the press*).
10. Ufra disease of Rice, E. J. Butler. *Agri. Journ. of India*, VIII, No. 3 (*in the press*).
11. A Sclerotial disease of Rice, F. J. F. Shaw. *Mem. Dept. of Agri., India*, Bot. Ser., VI, No. 2 (*in the press*).
12. Red Rot of Sugarcane, E. J. Butler and A. Hafiz Khan. *Mem. Dept. of Agri., India*, Bot. Ser., VI, No. 5 (*in the press*).

REPORT OF THE IMPERIAL ENTOMOLOGIST

(A. J. GROVE, M.Sc.)

I.—CHARGE AND ESTABLISHMENT.

I held charge of the section from July 1st, 1912, until the 29th, when Mr. H. Maxwell-Lefroy, Imperial Entomologist, returned from leave. Mr. Lefroy, however, resigned his post on the 30th of November 1912 and I took over charge from him on that date to officiate under orders of the Government of India until a new appointment was made, and have continued to hold charge since then. The First Assistant, Mr. C. S. Misra, was away on privilege leave from January 2nd until April 2nd, 1913. He has continued to be in charge of the field work on the Pusa Farm and the Botanical area, and has also instructed the long course students. The giving of two short courses in Lac Cultivation and the arranging of the general lac work has been in his hands. As well as this routine work, he has undertaken investigations on the occurrence of bollworms and their parasites in the experimental plots on the farm, arranging for the despatch of parasites to Egypt, and has also continued his work on economic *Aleurodidæ* and *Coccidæ*. The Second Assistant was on privilege leave from the middle of November to the end of December. He has remained in charge of the Insectary and assisted in the special investigation on indigo "Psylla." He has also done much useful work with the European and Indian bees. Mr. Dutt was on privilege leave from January 2nd to March 2nd, 1913. He has remained in charge of the economic collections and correspondence, a part of the General Collection (*Hymenoptera*), and the preparation and distribution of coloured plates and lantern slides, and has taken up a study of Hymenopterous parasites of crop pests. Mr. D. Nowrojee took privilege leave for 18 days during October and November 1912. He has remained in charge of the General Collections and has continued in-

vestigations on the biology of beetles affecting stored products. Mr. M. N. De has continued in charge of the Silk House and has carried out the hybridisation work with Mulberry silkworms and has also assisted in the preparation of sample silk pieces with both Eri and Mulberry Silk.

II.—Training.

The private student deputed by the Department of Agriculture, Travancore, continued his training until March 14th when he returned to his State for three months to study the particular pests of the State and returned on July 4th to work up the material he had collected and to continue his training. A student, deputed by the Assam Department of Agriculture, was admitted on November 1st, 1912, for training. A student from the Agricultural College, Giza, Egypt, was admitted on August 1st at the request of the Government of Egypt for a three months' training in practical entomology. Nine students have attended the short courses in Sericulture. Seven students attended the two short courses in Lac Cultivation, five in June and two in October.

III.—Research.

The investigation into the so-called "Psylla" disease of indigo was carried on and the practical results have been published. General enquiries into the biology and habits of insect pests have been continued and among those studied may be mentioned Painted Bug, Anar Butterfly, Termites (White-ants) and Bollworms and their parasites. An investigation has also been commenced, at the request of the Punjab Government, into methods for preserving wheat stored in bins from damage by beetles.

IV.—Insect Survey.

Additions have been made to the general collections during the year. Specimens of *Orthoptera* sent to Mr. Kirby, *Homoptera* to Mr. Banks, *Ichneumonidæ* to Mr.

Morley and *Psyllidæ* to Mr. Crawford for identification have been received back. Specimens of *Coleoptera* (*Longicornia*) were sent to Mr. Gahan and *Cantharidæ* to Dr. Wellman for identification.

V.—Provincial Work.

With the appointment of Entomological Assistants to the Provinces, Pusa is less in touch with the work done in the Provinces except in such cases where the Entomological Assistants submit monthly reports and where direct guidance is asked for. Also with the appointment of a European Entomologist to the Government of Madras, the necessity for controlling the work in that Presidency from Pusa no longer exists. It is to be regretted that Pusa is not in closer touch with the provincial work and the matter is under consideration, for it is advisable that there should be as complete co-ordination of the entomological work in India as possible in order to prevent duplication.

In the Central Provinces the rearing of Eri worms was continued and an effort was made to study sugarcane borers and the effect of growing maize as a trap-crop for them. In Bihar and Orissa the campaign against the greasy Cut-worm, *Agrotis ypsilon*, was successfully carried out. Arrangements were also made to make more traps locally and to start work against the Cut-worm at Bhagalpur and Colgong during the following year. Potato storage experiments were made at Bettiah, Bihar, Bhagalpur and Colgong, and demonstration godowns were started at Colgong and Bhagalpur. The rearing of Eri worms was continued and eggs were distributed to the local zemindars. In Baroda, work on checking the "Katra" and the sesamum stem-borer was continued. Field demonstrations were also given in several villages to check cotton bollworms, the sesamum stem-borer and the tobacco stem-borer. Arrangements were also made to start lac cultivation on *Babool* in the State and to procure *Babool* brood-lac locally.

VI.—Special Investigations.

(1) *Insecticides.*—Various proprietary preparations have been received for trial and reported upon. Many of these are found either to fall short of what is claimed for them or to be unsuitable for use in India.

(2) *Sericulture.*—The experiments with European Univoltine races have been continued and have given satisfactory results. The eggs which, as reported last year, were sent to places in the hills, where the temperature is not so extreme as on the plains, for storage during their dormant period, have turned out very well and given as good results as those which were cold-stored in a refrigerator in Calcutta. The hybridisation work with mulberry worms has been continued and more satisfactory results have been obtained.

Eri silkworms were again reared with good results, except during the hot dry months when conditions are extremely unfavourable. With this industry there is great need for better organisation both with regard to the distribution of seed and the disposal of cocoons. Efforts have been made to make arrangements whereby small rearers can dispose with advantage of the small quantities of cocoons they produce, but much closer co-operation among the rearers will be necessary before this can be done satisfactorily. The necessity, too, of a certain supply of reliable eggs has been felt this season and it is hoped that arrangements to overcome this difficulty may be made in future.

Requests for mulberry and castor seeds, disease-free Mulberry and Eri eggs, samples of cocoons, yarn, cloth, pamphlets, etc., have been received from numerous applicants, whose requirements have been supplied as far as possible. Sample pieces of both Eri and Mulberry silk cloth have been prepared and dyed with alizarin colours to show Indian weavers the possibilities of these silks.

Exhibits were sent to Muzafferpore, Bankipur, Malda, Banjettia, Ellore, Calcutta and Bangalore.

(3) *Lac culture.*—Two short courses in lac cultivation were given. The collection of lac insects from Forest

Officers for the determination of the species of lac insects has been continued and the series from most ranges are now almost complete. *Ber* and *Kusumb* plants, inoculated with lac insects, were again sent to Japan. Brood-lac was sent to Ceylon. Numerous enquiries about lac cultivation were received and answered. The Bulletin on the "Lac Cultivation in the Plains of India" is being translated into Hindi and Urdu. Experiments to determine other food-plants of the *Ber* lac have been carried out and are still in progress.

(4) *Apiculture.*—The experiments with European bees have been continued, but this year particular attention has been directed to obtaining fertilized queens. A large number of experiments were made and in all twenty-five queens were reared, but of these only two were successfully fertilized. Although this result seems rather poor, a large amount of valuable experience was obtained and it is hoped that when the proper season again comes round more successful results will be obtained.

The experiments with the Indian bee, *Apis indica*, were continued, but much progress was still impossible owing to the lack of suitable appliances. A foundation mill has now been obtained and it is hoped that during the next honey flow a satisfactory test of their honey-gathering qualities will be made.

VII.—Demonstration.

Owing to lack of funds no new coloured plates were issued during the year. Additional copies of the plates already published were issued to the Directors of Agriculture, Bengal and the Central Provinces, and to the Principal, Agricultural College, Nagpur. Sets of coloured lantern slides were supplied to the Director of Agriculture, Bengal, Principal, Agricultural College, Nagpur, Entomological Assistant, Baroda State, and the Assistant Professor of Entomology, Agricultural College, Lyallpur. The Department of Agriculture, Bombay, have indented for a large supply of coloured plates and arrangements have been made to supply these.

A demonstration of the use of spraying machines was given at various Indigo Factories in Bihar in connection with the treatment of indigo " Psylla."

VIII.—Correspondence.

Much time is still devoted to dealing with the numerous applications received for information, advice and the like, in the many branches of entomological endeavour dealt with by this section, but such correspondence is still given the greatest possible attention because of its great utility to officials and the general public. Eighty parcels of specimens were received from various applicants during the year and the fullest information possible was supplied in each case.

IX.—Visitors.

The Hon'ble Sir K. G. Gupta, K.C.S.I., Member of the Secretary of State's Council, and the Hon'ble Sir Charles Bayley, K.C.S.I., Lieutenant-Governor of Bihar and Orissa, visited the section in November and January respectively. Dr. L. H. Gough, Entomologist to the Department of Agriculture, Egypt, worked in the Laboratory in September and visited Baroda and Cawnpur during August with the First Assistant, to make arrangements for the despatch of bollworm parasites to Egypt. Mr. A. Alfieri visited Pusa from July to September on behalf of the Khedivial Agricultural Society of Cairo in connection with bollworm parasites. Lala Bishembar Das, Assistant Professor of Biology, Government College, Lahore, worked in the Laboratory from October to December. Lala Madan Mohan Lal, Assistant Professor of Entomology, Agricultural College, Lyallpur, spent three weeks in the Laboratory during October. The Entomological Assistant of Baroda visited Pusa in April to discuss his programme of work for the ensuing year. Mr. N. N. Pillai, Weaving Expert to the Government of Bengal, visited the Silk House during April. Mr. Cook, Principal of the Weaving School, Benares, inspected the dyeing work carried out in the Silk House.

X.—Programme of work for 1913-14.

As previously, investigations into crop pests and suggesting of remedial measures will be continued, and accounts of their life-histories, etc., will be published as material accumulates. The short courses in lac cultivation and Eri and Mulberry silk cultivation will be given as formerly, and also the training of students in general entomology. The cultivation of lac for experimental and demonstration purposes will be continued. The work with Mulberry silkworms will be carried on. Eri worms will be reared and help and advice on both Eri and Mulberry cultivation will be afforded as far as practicable. Experiments with European bees, especially from the point of view of queen raising, will be continued. It is hoped that it will be possible to test the honey-gathering qualities of the Indian bee, *Apis indica*, during the coming spring. Insecticides and apparatus, sent in for trial, will be tested and reported upon. The field experiments with wheat and sugarcane will be continued. If funds are available more coloured plates will be published and the work of preparing lantern slides will be continued. Where desired, help will be given to the Provincial Assistants in their work, and in case of serious outbreaks of pests special assistance will be given. The special investigations with insects attacking stored wheat will be continued as also the experimental work with cotton bollworm.

XI.—Publications.

1. Tetriginæ (Acridiinæ) in the Agricultural Research Institute, Pusa, with descriptions of new species. Dr. H. L. Hancock ~~Gough~~. *Mem. Dept. of Agri., India,* Ent. Ser., Vol. IV, No. 2.
2. The Big Brown Cricket (*Brachytrypes Achatinus*, Stoll). C. C. Ghosh. *Mem. Dept. of Agri., India,* Ent. Ser., Vol. IV, No. 3.
3. Life-histories of Indian Insects.—IV (Hymenoptera). G. R. Dutt. *Mem. Dept. of Agri., India,* Ent. Ser., Vol. IV, No. 4.

4. Inquiry into the Insecticidal action of some Mineral and other Compounds on Caterpillars. H. M. Lefroy and R. S. Finlow. *Mem. Dept. of Agri. in India,* Ent. Ser., Vol. IV, No. 5.
5. Cultivation of Lac in the Plains of India. C. S. Misra. *Bull. 28, Agri. Res. Inst., Pusa. (Second Edition in the press.)*
6. Directions for the Cultivation of Eri Silk. *Bull. 29, Agri. Res. Inst., Pusa. (Second Edition in the press.)*
7. Litchi Leaf Curl. C. S. Misra. *Agri. Journ. of India,* Vol. VII, Pt. III, July, 1912.
8. The "Psylla" disease of Indigo in Bihar. H. M. Lefroy. *Agri. Journ. of India,* Vol. VIII, Pt. I, January, 1913.
9. The Red Spider on Jute. C. S. Misra. *Agri. Journ. of India,* Vol. VIII, Pt. IV (*in the press*).
10. Life-history of Helicomitus dicax. C. C. Ghosh. *Bom. Nat. Hist. Soc. Journal (in the press).*
11. Instructions for rearing Univoltine Mulberry Silkworms. M. N. De. *Bull. 39, Agri. Res. Inst., Pusa (in the press).*
12. Life-histories of Indian Insects.—Lepidoptera. C. C. Ghosh. *Mem. Dept. of Agri. in India,* Ent. Ser., Vol. V, No. 1 (*in the press*).

Publications in preparation:—

Memoir on Indigo Psylla.
Memoir on Orthoptera.
Memoir on Coleoptera.
Memoir on Heterocera.
Memoir on Hemiptera.
Memoir on Insects Injurious to Indian Agriculture, revised edition.
Memoir on Indian Economic Aleurodidæ.
Bulletin on Fruit Pests.
Bulletin on Bees and Bee-keeping.
Vernacular translation of Bulletin No. 28 (revised edition) on the "Cultivation of Lac in the Plains of India."

REPORT OF THE IMPERIAL PATHOLOGICAL ENTOMOLOGIST

(F. M. HOWLETT, B.A., F.E.S.)

I.—ADMINISTRATION.

I was in charge of the section throughout the year, but spent two months in September and October on privilege leave.

Of the work which is summarised in this report, I owe not a little to the stimulus of frequent correspondence, conversation and collaboration with many medical officers more or less directly engaged in entomological work. The probable severance of these relations in the near future is to me a source of regret.

II.—VETERINARY WORK.

In January I circularized all Provincial Directors, enquiring whether there was any veterinary research in progress which I could assist from the entomological side, or any special direction in which they would suggest that entomological investigation should be prosecuted. The majority replied that the services of an entomologist were not at present required; Madras, Burma and the Central Provinces referred to the collection of possible Surra-carriers, and the Central Provinces also mentioned the parasites of sheep.

Major Holmes proposes an investigation of the insect carriers of Surra at Kathgodam. An assistant has been given special training in order that he may assist by carrying on the rearing of Tabanidæ and other blood-sucking Diptera which will be required in this enquiry.

A large collection of Ticks, mostly from Veterinary Officers of the different provinces, has been consigned to Professor Nuttall at Cambridge, there to be examined and identified in connection with Professor Nuttall's monographs on the subject which are now appearing.

An attempt was made to repeat the observations of Hindle and Merriman on the smell-reactions of Ticks (*Argas* and *Hyalomma*), but I was unable to obtain the same results. The matter is one of considerable interest, and I propose to return to it.

III.—Agricultural Work.

This was practically confined to the subject of fruit-flies of the genus *Dacus*.

A poison-spray method, which depends for its efficacy on the habit of the peach-fly (*D. Zonatus*) of sucking tentatively at any little drop of moisture on a leaf, was tried with excellent results. The proportion of affected peaches in the sprayed plots was approximately 2 per cent. over the whole period of picking, in place of the usual 45—60 per cent. The cost of the method is very small compared with the value of the crop, and should this year's results be confirmed by another season's work, they will have a very considerable commercial importance.

In the course of experiments on the chemotactic reactions of male fruit-flies I have found that these insects are strongly attracted by certain compounds allied to Eugenol ($C_{10}H_{12}O_2$). These compounds thus constitute a means of detecting the presence of the flies in a given locality with a degree of certainty quite unattainable by any ordinary method of observation.

Using this chemical test in the course of a tour in March through Bihar, the United Provinces, the Punjab, and the North-West Frontier Province, I found that the North-Western limit of the distribution of peach-fly practically corresponded with the South-Eastern limit of successful peach-growing.

Mr. and Mrs. Howard have shown that under the climatic conditions which obtain at Pusa it is possible to grow first-rate peaches. That peaches are not largely or profitably grown in the Southern and Eastern portions of the Gangetic Plain and in various districts in Southern

India is, I believe, due very largely or entirely to the abundance of peach-fly, 50 per cent. or more of the crop being almost invariably maggotty. It thus appears probable that the application of the poison-spray method may result in opening up, for the profitable cultivation of sound peaches, large areas where such cultivation is at present impossible owing to the ravages of the fly.

IV.—Medical Work.

The two genera concerning which information was chiefly desired by the Medical Department were *Stegomyia* and *Phlebotomus*.

A course of instruction in the identification, breeding and general observation of *Stegomyia* was given in July to Medical Officers engaged in the "Stegomyia survey." The life-histories of all the species occurring at Pusa have been worked out in their main features. Careful observations have been carried on throughout the whole year on the seasonal prevalence of the different species, and it has been established as a practical certainty that all species are normally in the habit of tiding over periods of drought as dry eggs, even though these periods may be of six months or even longer duration.

Anti-*Stegomyia* operations have been carried out at Pusa, with a very marked result on the numbers of these mosquitos, which in past years have been invariably very troublesome in the rains. This year it is rare to find them in the bungalows.

The methods adopted have been the filling up with earth or plaster of Paris of all known or probable breeding-places, particularly holes in trees and cut bamboos, and the simultaneous provision of "trap-breeding-places" in the form of bamboo-joints filled with water which are emptied out as soon as larvæ make their appearance in them. I regard this trapping method as a distinct advance on mere indiscriminate destruction, and with modifications it might be found a valuable aid in anti-malarial operations.

Coloured plates were prepared illustrating all stages of the life-history of the different species of *Stegomyia* and allied genera occurring at Pusa, and a set of maps was also constructed, largely from information received from Medical Officers on the Stegomyia survey, showing the known distribution of the different species in India. These plates and maps, together with specimens of the mosquitos in different stages and other exhibits, were sent at the request of the Medical Department to the International Exhibition at Ghent to form a part of the Indian exhibit in the section of Tropical Medicine and Hygiene. A typical collection of mosquitos and other human parasites was also sent to Dr. Marzinowsky of Moscow.

A large number of observations have been made as to the action of different chemical substances on the eggs and larvæ of mosquitos (*Stegomyia scutellaris*, *Myzomyia rossii*, and *Culex fatigans* and *microannulatus*).

It has been found that ordinary powdered Calomel (mercurous chloride) has many of the properties of the ideal larvicide, and this substance certainly merits a more extended trial to ascertain its cost and efficacy under field-conditions. The action is comparatively slow, but sure and apparently lasting, while the amount which it is necessary to use is so minute that treated water is in no way harmful or uncomfortable for ordinary use by men or cattle.

Observations have also been made on the method of feeding and the nature of the food and digestion of mosquito-larvæ, and on the respiration and oxygen-consumption of larvæ and pupæ. Methods of colouring mosquitos for identification in flight-determination have been tried with success as far as permanence and ease of identification are concerned, both carmine powder and gentian-violet giving good results.

The breeding of West Indian " Millions," obtained in the first instance from the Officiating Sanitary Commissioner of the United Provinces, though quite successful under " semi-domestic " conditions, has been a failure when

the fish have been transferred to large *pucca* tanks. This seems to be owing to the attacks of the larvæ of large Dytiscid water-beetles which are common here, and which destroy the young fry and even the adult fish. It is probable that the native *Haplochilus* is, under Indian conditions, at least as effective a larva-destroyer.

With regard to sand-flies (*Phlebotomus*) the life-histories of *Phlebotomus papatasii*, *P. argentipes*, and *P. minutus* have been worked at.

Attention was mainly directed to *P. minutus*, which is the commonest species at Pusa, and a large amount of time has been spent in the difficult task of discovering natural breeding places. The preliminary results of this enquiry were presented in a paper read at the Malaria Conference at Madras.

By combining these results with those obtained in a series of experiments on the predilections of the larva and of the fly for various foods and for different hosts, it appeared probable that there was some connection between the fly and the wall-lizards or Geckos commonly found on tree-trunks and the walls of bungalows. Subsequent observations have shown that this supposition is correct, and that there is undoubtedly a close connection at several points between these reptiles and *P. minutus*. In a paper contributed to the " Indian Journal of Medical Research " I have put forward the view that the " real " hosts of this sand-fly are lizards, and that the connection with man may be of a secondary nature.

Attention has lately been directed to the hosts attacked by *P. argentipes*, as little is known of the biting habits of this species, but no very definite results have yet been obtained. *P. papatasii* will be most easily investigated in the Punjab or North-West Frontier Province, where it is far commoner than at Pusa. The results obtained through the excellent work of Professor Newstead and Captain Marett in Malta will probably be found applicable to India, and can be taken as a basis for further investigation of the habits of this species.

At the end of the rains I spent some time in Poona in company with Captain Morison, I.M.S., and inspected the breeding-grounds of Muscid flies which were suspected of a connection with a form of enteritis prevalent at Poona. Experiments on marked flies were carried out to ascertain how far the city trenches were responsible for the very great abundance of flies in the city and cantonments. An assistant was deputed to remain at Poona and assist Captain Morison in the investigation of breeding-places and the other entomological work necessary. An assistant was similarly deputed to assist Major Greig, I.M.S., in his investigation of typhoid fever at Puri, and the part played by flies in its transmission. In collaboration with the Medical Officer at Pusa observations are being made on the flies responsible for the cases of myiasis which are somewhat common in the district.

One assistant attended the malaria class, under Captain Hodgson, I.M.S., at Delhi. A large number of mosquitos and other insects, sent in mainly by Medical Officers, have been identified. I gave a series of lectures with practical instruction on methods of drawing and illustrating.

In November I had the pleasure of attending the Malaria Conference at Madras and read three papers :—

"The yellow-fever mosquito."

"The breeding-places of Phlebotomus."

"Insect psychology and its bearing on methods of control."

Two papers have been contributed to the first issue of the "Indian Journal of Medical Research" :—

"The natural host of Phlebotomus minutus."

"Insect life-histories and parasitism."

V.—Programme for 1913-14.

Fruit-flies and Parasitic Insects.

REPORT OF THE IMPERIAL AGRICULTURAL BACTERIOLOGIST

(C. M. HUTCHINSON, B.A.)

I.—ADMINISTRATION AND TOURS.

I held charge of the section throughout the year excepting three weeks' privilege leave in September, when Mr. Joshi was in charge.

The staff was considerably strengthened by the sanction of the following additional appointments :—

Supernumerary.—Mr. J. H. Walton, B.A., B.Sc., was appointed as Supernumerary Agricultural Bacteriologist, and joined this section on 25th October 1912.

Assistants.—Two posts of Assistants on Rs. 75—125 each were sanctioned; one was given to Mr. C. S. Ram Aiyer, B.A., an Assistant in this section; and the other to Mr. N. C. Bose, an Assistant in the Chemical Section. Mr. Bose was appointed in this section on 18th April 1913. Mr. N. Dayal Singh was appointed in this section, as Fieldman, on 1st May 1913.

Mr. Vishwanadham, Second Assistant, was on privilege leave from 25th March 1913 to 27th April 1913. Mr. Ram Aiyer, Third Assistant, was on privilege leave from 8th July 1912 to 20th August 1912.

The outside laboratory building was completed and work commenced in it in June 1913; Mr. Vishwanadham, Second Assistant, has been put in charge of this building. It is primarily intended for pot-cultures and work on ammonification and nitrification in soil media; an important feature is the locally made pressure sterilizer capable of sterilizing six large or twelve smaller sized culture pots simultaneously under 40 lbs. steam; this will also be available for use by the Mycological Section.

The compound attached to this building will be used for experimental plots; pits for growing rice under varying

conditions of water supply have been made and are now in use; green manure (sann) has also been grown for experimental purposes.

Tours.—To Muktesar to discuss various matters connected with bacteriological technique in India with the Imperial Bacteriologist.

To Muzafferpore to attend meeting of Bihar Planters' Association.

To Nagpur to examine soil conditions and obtain samples from sewage treated area.

To Bettiah to investigate potato disease.

To Sirseah to consult Mr. Bergtheil on the subject of indigo disease.

II.—Soil Bacteriology.

Nitrogen supply in the soil as affected by intervention of bacteria has been the principal subject of enquiry; in the previous year attention was confined to the conditions under which organic nitrogen of manures and residues is converted into ammonia and nitrates; this line of enquiry affords sufficient work to occupy the whole time of any establishment for many years, but it has been considered advisable to add to it an investigation of the natural conditions under which nitrogen is taken from the air and added to the soil in this country. This if carried out thoroughly would also involve a very large amount of work, but it seems advisable in dealing with such a question as soil bacteriology in this country, where no work on this subject has been carried out before, to make preliminary enquiries, however superficial, on similar important questions, in order to gain some idea of the most useful direction in which to pursue the subject more fully. This is the more necessary on account of the still early stage of development of soil bacteriology as a science, and the fact that many fundamental theories connecting bacterial action with soil fertility have not yet been accepted as axiomatic. It is perhaps unnecessary to emphasize the importance of the question of nitrogen fixation, but it may be pointed out

that there is very good reason for supposing that upon this depends the ultimate prosperity of a country, the mineral wealth of which not being commensurate with its agricultural area and population debars it from the purchase of adequate supplies of nitrogen from external sources. At the present time the need of nitrogen in India is becoming increasingly greater owing to the introduction of intensive cultivation, although up till now the soils of this country as a whole have been preserved from undue depletion by the generally superficial and extensive nature of the cultivation employed, which has prevented large crops from being taken off the land, after the reduction of the original virgin soil to the normal level of fertility by the growth of crops. At the same time deportation of nitrogen in the form of produce exported from areas in which it was grown has not been excessive, and in the case of rice much fertilization of the soil takes place by deposition of organic matter carried down from jungle tracts by the irrigation water. Nowadays, however, this state of affairs is being rapidly altered owing to the expansion of Indian trade, which not only transports foodstuffs from agricultural districts to feed the increasingly large populations of cities, but carries enormous quantities of produce out of the country, including not only cereals, oilseeds and fibres, but bones and hides which represent nitrogen collected from very extensive areas of land. If now, in addition to this constant drain upon the nitrogen resources of the soil, intensive cultivation is introduced, meaning the more rapid conversion of non-available plant food, especially nitrogen, into the available condition, depletion will certainly follow, differing in intensity from such a result in temperate climate as the average soil temperature in India differs from that in Europe, but in an even higher degree. This difference due to temperature has been observed and measured in this laboratory as affecting ammonification, nitrification, and the formation of carbon dioxide by oxidation of the organic matter of the soil, and is not one of a slightly higher degree, but may easily attain to an increase

in rate of one hundred per cent. or more; the concurrent loss of nitrogen is not to be measured, therefore, only by the increased crops taken off the land, but by losses in the form of ammonia and of nitrate washed out during the rains from fallows in well drained areas.

A further point must not be overlooked; on the credit side of the nitrogen account must be placed the addition of this element to the soil through the intervention not only of leguminous plants, but of nitrogen-fixing members of the soil flora such as Azotobacter and Clostridium; the physiological activity of these organisms, however, is strictly limited by soil conditions, and especially in the case of the former by the supply of carbohydrate food, so that should intensive cultivation, carried out without regard to this aspect of the case, lower the supply of organic matter beyond the optimum point for nitrogen fixation by the above-mentioned organisms, this source of nitrogen would be cut off, and the discrepancy already existing between the two sides of the account would be further increased, probably in geometric proportion.

During the past year Azotobacter has been found in all Indian soils examined, including those of such widely differing character as may be found in Sind, Nagpur, and Assam; pure cultures of *A. Chroococcum* from such various sources exhibited nitrogen-fixing power very similar to that recorded from European strains, its physiological activity depending upon appropriate supplies of water, air, lime and especially of carbohydrate food. It is intended to carry out a general survey of Indian soils to get some idea of the distribution of this and similar organisms and the conditions under which they may most readily carry on nitrogen fixation in these soils.

The green manuring experiment begun in collaboration with the Imperial Agriculturist during the previous year was carried on, and will continue in 1913-14. The successful use of a green manure crop was found to depend almost entirely upon the incidence of the rainfall succeeding the burying of the crop, partly owing to the loss of

soil moisture by transpiration during the growth of the green manure, and partly to the necessity for providing a considerable percentage of soil water to ensure the proper decomposition of the buried material. Further experiments during the current season include a special method of dealing with a green manure crop designed to avoid the loss due to want of sufficient soil moisture to ensure complete decomposition after burying; this method consists in hastening the initial stages of decomposition by steeping the cut crop in water and then fermenting it in heaps, under which conditions the less readily decomposed cell walls and lignified tissues are rapidly attacked by bacteria favoured by semi-anærobic conditions; the fermented material is then used in the same way as farm yard manure. The advantages of this method, in addition to the principal one of eliminating the uncertainty of the rainfall as a factor in decomposing the buried green material, include the possibility of applying the fermented manure at the best rate per acre and at the best time for producing its optimum manurial effects; at the same time it is not necessary to grow the green manure crop on the land which is to carry the "rabi" crop intended to benefit by its manurial effect; in some cases this might be of great advantage with regard to the depletion of the soil moisture consequent on transpiration during the period of growth of the green manure crop. This method of dealing with a green manure crop closely resembles the practice in indigo-growing districts of manuring tobacco and other soils with the refuse ("Seet") from the indigo factory, which is obtained by steeping the cut indigo plant in water for some 24 hours and subsequently allowing the sodden plants to lie in heaps in which fermentation goes on; the rotted material thus produced is generally applied to tobacco lands, the rented value of which depends almost entirely upon the local availability of the indigo "Seet."

The field experiments with green manure in 1912-13 included the growth of a "rabi" crop (wheat) on the experimental area. In no case was there any increase in

yield from the green manured plots, and in many there was a decided falling off. There can be no doubt that this result was due to the failure of the generally expected rainfall in September and October (locally known as the "Hathia") as it was found on examination that the buried stems of the green manure had failed to undergo complete decomposition.

Laboratory experiments showed that the nitrate formed from the buried plant tissues increased in amount up to the end of eight weeks from the time of turning into the soil, provided the water supply was kept up to at least 16 per cent. of the soil weight, but after this period a steady diminution took place, so that after twelve weeks a smaller quantity of nitrate than that present at the end of the eighth week was invariably found. The cause of this loss was not discovered, although it may be conjectured that it was due to the demands of the soil organisms for nitrogen, but its invariable occurrence is interesting as helping to explain the already well-known fact in field practice that too long an interval between the burial of a green manure and the sowing of the succeeding "rabi" crop is prejudicial to the latter so far as any improvement which may be expected from the use of the former is concerned.

The results of the first year's experiments on green manuring will be published in the form of a Bulletin.

Further work on the occurrence of bacterio-toxins in soil, their relation to infertility, and the action of tillage, drainage, and manurial application in neutralizing them, was carried out.

Biological analyses of various soils were made and further modifications of the method introduced; this subject is still in a very early stage of development, especially so far as interpretation of results is concerned, but it is hoped that further experience and modification of the method will lead to its successful application to the solution of various soil problems. At present it is possible to determine the optimum moisture content of a soil for

certain biological processes necessary for fertility, to ascertain approximately the organic manures most suitable for application, with the important reservation that the sample experimented on may not be truly representative of the area to be treated; this source of error is greatly minimised by the use of large samples and the introduction of the method of using soil media in place of inoculating liquid media with small samples of soil; thus in the old method one gram of soil was generally used as inoculum and the biologic activity of the soil as a whole was judged therefrom, whereas in the method now used, estimations of nitrifying and ammonifying capacity and efficiency, and general biologic activity, are made with samples varying from 400 grams to 1,200 grams.

III.—Special Enquiries.

(1) *Sewage Farms.*—At the request of the Principal of the Agricultural College, Nagpur, a series of investigations was commenced with a view to determining the effects of the application of sewage upon the biological condition of the soils of the College Farm. I visited Nagpur and inspected the farm soils and the sewage installation, and discussed with Mr. Allan and Mr. Plymen, the general arrangement of the experimental plots to be put under treatment. An arrangement was made for sending periodic samples to Pusa for examination, and at the same time Mr. Plymen agreed to carry out chemical analyses to determine nitrate at Nagpur.

(2) *Rice.*—An experiment was arranged to determine the effect of soil toxins upon the growth of the rice plant; this was in connection with the work of the Imperial Mycologist upon the "Ufra" disease of this crop, as it was considered possible that the incidence of this disease might depend upon adverse soil conditions. Rice was grown in pots in soil to which large quantities of mustard cake were added, it having been found that the initial stages of decomposition of this manure give rise to bodies which are toxic to plants. The pots were arranged so that

in one set lack of drainage should allow of accumulation of the toxins produced, whilst in the other continuous percolation removed them in solution. The results completely verified expectation, as not only was growth seriously interfered with in the undrained pots, but the root formation in the drained set showed that the toxins carried down by the percolating water had inhibited root growth in the lower soil, whereas in the undrained series more root development took place below than above. No symptoms of "Ufra" appeared, but Dr. Butler has now demonstrated conclusively the connection between this disease and the presence of nematodes in the plants, nor does it appear that soil conditions adverse to healthy growth render the plants more liable to attack.

(3) *Tobacco.*—The work on Tobacco Wilt in the Rangpur District was concluded and a Memoir on the subject published in the Bacteriological Series.

(4) *Indigo.*—Plants of Java variety were grown and kept under observation for symptoms of wilt in order to determine a possible bacteriological origin of this disease; this work will go on through current season.

(5) *Potato Rot.*—An extensive series of investigations was carried out, mainly by Mr. N. V. Joshi, First Assistant, as to the cause responsible for the very common rotting of tubers in store. The Economic Botanist to the Government of Bihar and Orissa, at whose instance this work was undertaken, provided samples from various godowns in Bihar, and others were received from Poona. Two rotting bacteria were found to be present invariably, and these appear to be normal in Indian soils. It was found that rotting could take place in presence of these bacteria either if the dry tubers suffered mechanical injury or if the uninjured tuber were kept under conditions in which its surface could remain moist for a few hours. Thus tubers stored in sand to keep out potato moth can be attacked if the rotting organisms are present, either through bruising due to careless handling or by reason of the sand not being perfectly dry, or by contact between a rotting

potato exuding moisture and a sound one; this last possibility necessitates frequent examination of stored tubers and picking out of rotten ones. Various antiseptics were tried on a small scale, of which copper sulphate proved the best; this will be tested along with other preventive measures in the ensuing season.

IV.—Programme of work for 1913-14.

A.—Biological aspects of soil under—

(1) Treatment with green manures.
(2) Rice cultivation.
(3) Sewage.
(4) Varying methods of tillage.

B.—Disease of indigo and solanaceous plants.

C.—General work on biology of soils and biological analysis.

D.—Training of students.

V.—Publications.

1. Rangpur Tobacco Wilt. C. M. Hutchinson. *Mem. Dept. of Agri. in India,* Bact. Ser., Vol. I, No. 2.
2. Drainage in Rice Soils. C. M. Hutchinson. *Agri. Journ. of India,* Vol. VIII, No. 1, January, 1913.

REPORT OF THE IMPERIAL COTTON SPECIALIST

(G. A. GAMMIE, F.L.S.)

I.—CHARGE AND TOURS.

I held charge of the appointment of Imperial Cotton Specialist throughout the year.

During the month of October 1912 I visited the North-West Frontier Province to discuss present and future operations in cotton cultivation with the Revenue Commissioner and the Superintendent of Farms. In November I attended the annual meeting of the District Agricultural Associations at Akola, where I met the Director and Deputy Director of Agriculture of the Central Provinces and then went on to Nagpur to confer with the Economic Botanist regarding his work on the improvement of his provincial cottons. In December I accompanied the Director and Deputy Director of Agriculture, Bombay, on a tour to all the experimental stations in Guzerat where we had ample opportunities of discussing matters on the ground greatly to our mutual benefit and understanding. In March I was on tour with the Director and Assistant Deputy Director of Agriculture in the Southern Mahratta Country and here again we had an opportunity of settling many points of interest in the fields. In April and May I was on tour in Guzerat with the Deputy Director of Agriculture. The intervening periods throughout the year were spent at head-quarters, supervising my own experimental station, arranging for the distribution of seeds required by many correspondents and also for the valuation of samples of cottons received from all parts of India.

II.—COTTON IN THE PROVINCES.

(*a*) *North-West Frontier Province.*—The following are my notes drawn up after a visit to this province. The

local variety of cotton is so productive and in every way so suitable to this province that I would not suggest replacing it by any other variety—either Indian or foreign. It is a mixture of varieties of the *neglectum* type and we agreed that the plants with narrow lobed leaves and pendulous lint should be selected and of these the best plant should be taken as the parent of the future stock. The red flowered cottons (*Multan*) may prove to be remunerative if they ripen in time, but, as this is doubtful, I should emphasize the necessity of the Department confining its trials to one type of plant. The value of this advice will be fully appreciated when seed in sufficient quantities is available for distribution. Then there is only one sort to deal with and mistakes and mixtures cannot possibly creep into the work.

The American cottons, as plants, are well grown but will not ripen their bolls. So far as we can at present judge, there are no great possibilities for exotic cottons in this tract, but there need be no discouragement on this score as the local product is quite satisfactory.

(*b*) *Punjab.*—Samples of 22 varieties were submitted to Messrs. Tata, Sons & Co., Bombay, for valuation and I append a copy of their report. These cottons have been grown on the Lyallpur Farm for several years and it is now time that some action should be taken in the selection and multiplication of the most promising for distribution to cultivators.

Valuation furnished by Messrs. Tata, Sons & Co., Bombay, on the 22 samples of cotton grown on Lyallpur Farm, on 15th May 1913.

Serial No.	Sample No.	Remarks.
1	7F	This cotton equals Middling American in colour, staple and strength, only it is slightly coarse to the feel. It can spin 40s. We value it at Rs. 350 per candy, say the price of Middling American cotton laid down in Bombay.
2	70F	Slightly shorter than No. 1 in length of fibre; in all other respects it is equal to the above. It can spin 30s—32s. Value Rs. 335.

Valuation furnished by Messrs. Tata, Sons & Co., Bombay, on the 22 samples of cotton grown on Lyallpur Farm, on 15th May 1913—contd.

Serial No.	Sample No.	Remarks.
3	72F	This is really an excellent cotton of a quality superior to Middling American. It can easily spin 50s and our valuation is Rs. 400 per candy.
4	110F	This cotton is hardly superior in spinning quality to Fine Surats. The fibre is weaker than No. 2 and cannot spin over 22s. Value Rs. 350.
5	111F	It resembles No. 1 in all respects, only the fibre is slightly stronger. It can easily spin 40s. For strength of staple we value it Rs. 10 over the price of No. 1, say Rs. 360.
6	126F	This cotton resembles Fine Surats in its spinning quality. It is stronger in fibre than No. 4 and can spin 24s. Value Rs. 325.
7	161F	It is slightly superior to No. 1 and can easily spin 40s. We value it at Rs. 360 per candy.
8	168F	It is the exact counterpart of No. 4. Will spin 22s. Value Rs. 320 per candy.
9	179F	This cotton lacks in body and has a different appearance than any of the above. It has, however, a soft feel though the fibre is of variable strength. On the whole it can spin 24s and may be valued at Rs. 325 per candy.
10	199F	Equals No. 2 in all respects. Can spin 30s—32s. Value Rs. 335.
11	112F	Same as above. Will spin 30s—32s. Value Rs. 335.
12	211F	Equal to No. 6 in all respects. Will spin 24s. Value Rs. 325.
13	226F	It is equal to ordinary Fine Broach, only it is superior in colour. It will spin up to 20s. Value Rs. 295—Rs. 3 being added to the price of Broach for colour.
14	232F	Same as above. Will spin up to 20s. Value Rs. 295.
15	233F	Equal to No. 2. Will spin 30s—32s. Value Rs. 335.
16	275F	Equal to No. 1. Can spin 40s. Value Rs. 350.
17	280F	This is an excellent cotton equal to No. 3. Will spin 50s. Value Rs. 410. We have added Rs. 10 to the value as we find that it is all round slightly better than No. 3.
18	281F	Equal to No. 1. Will spin 40s. Value Rs. 350.
19	282F	Equal to No. 3. It is an excellent cotton. Will spin 50s. Value Rs. 400.
20	266F	Equal to Surats in spinning quality. It is like No. 6. Will spin 24s. Value Rs. 325.

Valuation furnished by Messrs. Tata Sons & Co., Bombay, on the 22 samples of cotton grown on Lyallpur Farm, on 15th May 1913—concld.

Serial No.	Sample No.	Remarks.
21	..	*Deshi cotton, zamindari sample,* has all the characteristics of Sind Punjab cotton. It can spin up to 10s and we value it at same price as Fine Sind Punjab Ginned, namely, Rs. 245.
22	..	*American cotton, zamindari sample,* shows good deal of variation in the length as well as the strength of the fibre. It seems that proper attention was not paid to this cotton on the zamindari land, hence the deterioration. We pull out a sample from a handful of this sample which can easily spin 24s while another handful from the same sample gives a staple which can hardly spin 20s. We therefore conclude that this "Mixed Staple" will not spin beyond 20s and we value it at Rs. 315, say, Rs. 5 lower than our quotation of Surats.

Basis of prices on 13th May 1913 :—

	Rs.	
Middling American .	350	per candy of 784 lbs.
Good Tinnevelly .	330	,, ,, ,, ,,
Fine Surat . .	320	,, ,, ,, ,,
,, Broach . .	292	,, ,, ,, ,,

In forwarding this report I added the following remarks :—

"These cottons have now been successfully grown on the Botanical Experimental Farm for the past five years so that their suitability for your conditions has been abundantly established. From a practical point of view the distribution of the seed and subsequent supervision of the product of 20 selections is not possible and it would be as well to determine how few of these should be ultimately maintained.

Variety.	Remarks.
7F	Last year was compared with and valued equal to the best Surat cotton, or Rs. 45 per candy less than Good Middling American. This year it is valued as equal to Middling American laid down in Bombay at Rs. 350 compared on the same day with Good Tinnevelly, Rs. 330 ; Fine Surat, Rs. 320 ; and Fine Broach, Rs. 292.

Variety.	Remarks.
70F	Last year this was compared with the best Broach and valued at Rs. 5 more; this year it is reported to be worth Rs. 335 or Rs. 15 less than 7F.
72F	Last year was reported to have a characteristic and style of Best Surat, being slightly better than 7F in length of fibre, and it was valued at Rs. 5 higher than 7F, *i.e.*, Rs. 325 per candy. This year it is said to be an excellent cotton of a quality superior to Middling American and its valuation is Rs. 400 per candy.
110F	Last year this cotton was said to resemble the superior grade cottons grown in the Central Provinces such as Warora and Hinganghat on account of its being slightly dull in colour and was valued at Rs. 5 lower than Warora. This year the cotton is found to be hardly superior in spinning quality to Fine Surats and is valued at Rs. 320 (Rs. 350 in the report being an error).
111F	Last year was found to be equal to 7F. This year the same conclusions have been arrived at, but on account of the fibre being slightly stronger it is valued at Rs. 10 more.
112F	Last year was the same as No. 111F, but a shade shorter in the length of fibre, therefore valued at Rs. 5 less; this year it equals No. 70F.
126F	Last year it was said to be midway between the best Broach and Surat and valued at Rs. 10 more than Fine Broach. This year reported to resemble Fine Surats in spinning quality and valued at Rs. 325.
161F	Last year was considered to be the best of its kind grown in Indian soil and acclimatized in India. Valued at Rs. 385 against Rs. 365 for Good Middling American. This year it has been reported to be slightly superior to 7F and valued at Rs. 360, Middling American being Rs. 350.
168F	Last year and this year also reported to be hardly superior to Fine Surats.
179F	Last year reported to be equal to Fully Good Middling American. This year found to be lacking in body and with fibre of variable strength. Something has evidently happened to this number and it should be discarded.
199F	Last year valued at Best Broach style of cotton. This year it is said to be equal to 70F. This could be thrown out.
211F	Equals No. 126F and need not be kept up.
226F	Last year reported to be of the style of inferior cottons of the Central Provinces. This year is said to be equal to Ordinary Fine Broach.
232F	Last year and this year also reported as equal to 226F.
233F	Last year reported to be equal to 226F and this year equal to No. 70F. There is some discrepancy which should be inquired into.
275F	Last year said to be Broach style of cotton; this year is said to equal No. 7F.
280F	This year said to be equal to 72F or perhaps Rs. 10 better.
281F	Reported to be equal to No. 7F.
282F	Equal to No. 72F.
266F	Equal to No. 126F.

"*Basis of valuation* on 10th May 1912 :—

	Per candy of 784 lbs.
American Good Middling	7½*d.* c.i.f.
	Rs.
" " "	365 Net.
Fine Navasari	340
" Surat	320 "
" Broach	285
" Warora-Hinganghat (Central Provinces)	290 "
" Wardha	285 "
" Yeotmal (Berars)	280 "
Good Tinnevelly	320

"*Basis of valuation* on 13th May 1913 :—

	Per candy of 784 lbs.
Middling American	350
Good Tinnevelly	330
Fine Surat	320
" Broach	292

"Zamindari sample of *Deshi* cotton has all the characteristics of Sind Punjab cotton.

"American zamindari sample is reported to show good deal of variation in the length as well as the strength of fibre. It is valued at Rs. 5 lower than Surats.

"An analysis of the report of your samples brings to light the fact that Nos. 72F, 161F, 280F and 282F in point of quality are by far the most desirable and it is quite probable that no harm would be done if these are mixed and treated under one number. You will then have a cotton which would meet the requirements of manufacturers for a high grade class of cotton grown in India. The only important doubt which remains in regard to these is whether their production is on a par with the quality; but this is a point which you have no doubt worked out. If the production is really satisfactory, I would strongly recommend you to do as I have already suggested; mix these numbers already given, test them on a large field scale—and if the result is still satisfactory the seed could be produced on seed farms for distribution in large quantities to selected cultivators. If you wish to keep them up, a number of the inferior types in your list could also be

amalgamated; for instance, from the point of quality alone there is no particular reason for keeping separate Nos. 126, 168, 211, 266.

" You should bear in mind that, unless you distribute the seed of only one variety or type into each tract or district, you will soon receive complaints of mixed cotton from the traders and the cultivators will suffer."

(*c*) *United Provinces of Agra and Oudh.*—The following valuations of Messrs. Tata, Sons & Co., on samples from Mr. Burt, are interesting as they show the strong possibilities of ultimate success in the cultivation of American cottons in the United Provinces. Until we apply the crucial tests of acreage outturn, percentage of cotton to seed, and other factors to these varieties it is obviously unsafe to say whether all or any of them are really profitable to grow, and it is to be hoped that the United Provinces Department of Agriculture will soon furnish us with the required information. The experiments in progress on the indigenous varieties are identical with those we have carried out to a definite conclusion in Berar and Khandesh.

Valuation furnished by Messrs. Tata, Sons & Co., Bombay, on the four samples of cotton from Cawnpore, on 16th July 1913.

Serial No.	Remarks.
1	*Dharwar American.*—Dharwar American seed sown in Cawnpore soil shows marked improvement in staple, though the colour has deteriorated. We value it at Rs. 290, say Rs. 25 more than the price of Dharwar simply for its staple.
2	*Cawnpore American acclimatized.*—The above remarks apply to this sample too, only the staple is slightly shorter than that of No. 1. Value Rs. 285, Rs. 20 above the price of ordinary Sawginned Dharwar.
3	*Boyd.*—This cotton is equal in all respects to Middling American. We value it at 6¾*d.* per lb. laid down in Bombay, the equivalent in rupees being Rs. 350 per candy, Bombay terms.
4	*Black Rattle.*—This is a specially long stapled American cotton, equal to 1¼" Bender American in staple and to Good Middling in class. We value it fully ¾*d.* higher than Middling. Taking Middling at 6¾*d.* this cotton is fully worth 7½*d.* per lb., rupee equivalent being Rs. 400 per candy, Bombay terms.

Basis of value.—Fine Khandesh, Rs. 230; Good Sawginned Dharwar, Rs. 652; and Middling American, Rs. 350 per candy.

(*d*) *Central Provinces.*—I have reported so often and so fully on the excellent work done in this province that I have now little further to say. The outturn of the hardy indigenous varieties is so satisfactory and the product meets the demand of its market so well that there is no incentive to push the claims of longer stapled cottons, more specially as the conditions of soil and climate do not by any means favour these. An experimental farm for their cultivation may, however, be established in Western Chhattisgarh where conditions seem more favourable to exotic varieties.

Valuation furnished by Messrs. Tata, Sons & Co., Bombay, on the 9 samples of cotton from the Akola Farm, on 8th January 1913.

Serial No.	Name of variety.	Remarks.
1	Berar Jari .	Ordinary Akola type of cotton. It is slightly harsh in feel. Value Rs. 318.
2	Rosea No. 1 .	Slightly superior to No. 1 in staple. Value Rs. 322.
3	Cutchica No. 1	Equal to No. 1. Value Rs. 318.
4	Vera . .	It is better than No. 2, both in feel and length of staple. Value Rs. 325.
5	Malvensis .	Midway between Nos. 2 and 4. Value Rs. 323.
6	Bani No. 3 .	It has all the characteristics of stapled Berars cotton. It is silky and has a long, strong, even fibre. Value Rs. 355.
7	Saugor Jari .	A short stapled Oomra equalling Dhamangaum cotton in style and colour, but the staple is shorter. With Dhamangaum at Rs. 330 we value this at Rs. 325.
8	Bhuri I . .	A long stapled cotton equal to No. 6, but slightly weaker in fibre. Value Rs. 345.
9	Bhuri II . .	Same as No. 8, but the fibre is more weak. Value Rs. 340.

N.B.—We have compared Nos. 8 and 9 with a sample of Cambodia cotton which we have purchased lately at Rs. 325, and we have based our valuation of these two samples on this comparison.

Basis.—F. Akola good at Rs. 320 per candy.

Some of the cotton varieties from the Northern Division of the Central Provinces, already alluded to in previous

reports, have again been reported on from samples sent by Mr. G. Evans, the Deputy Director.

The following are Messrs. Tata's valuations; 10th April 1913 :—

Serial No.	Name of variety.	Remarks.
8	Saugor Jari (white flowered).	It is softer in feel than Khandesh, but inferior in staple. Value Rs. 268. (Basis Fine Khandesh, Rs. 272.)
9	Saugor Jari (yellow flowered).	Better in staple than No. 8, and we value it same as Fine Khandesh, *viz.*, Rs. 272 per candy.
10	Chhapara .	This sample may be classed as between Nos. 8 and 9. Value Rs. 270.
11 to 18	..	These 8 samples may be classed as Khandesh cotton. Nos. 11 and 12 are inferior in class and we value them at Rs. 265.
		Nos. 13, 15, 17 and 18 are worth Rs. 270 per candy. Nos. 14 and 16 show improvement in staple and we value them at Rs. 275 per candy. (Basis Fine Khandesh, Rs. 272.)

Nos. 8 and 9, Saugor *Jari*, white and yellow flowered respectively, again show the superiority of the staple from yellow flowered plants.

No. 10 is another local form discovered by Mr. Evans and its value lies midway between that of Nos. 8 and 9.

(*e*) *Madras.*—The following valuations of samples from the Nandyal and Hagari Experimental Stations show very graphically the rapid deterioration which takes place even in Indian cottons when their environment is altered. The necessity for a continuous importation of the seeds of such cottons is clearly demonstrated.

Valuations furnished by Messrs. Tata, Sons & Co., Bombay, on 21st September 1912.

Serial No.	Name of variety.	Remarks.
1	Northern .	Shows no improvement in Nandyal soil. It looks like Kumpta, but being picked from selected plants, the fibre is longer than that of Kumpta. With Kumpta at Rs. 290 we value this cotton at Rs. 310.

Valuations furnished by Messrs. Tata, Sons & Co., Bombay, on 21st September 1912—contd.

Serial No.	Name of variety.	Remarks.
2 to 9	Northern .	These are from the general crops and are very much alike except Nos. 2 and 6, which show a slight falling off in fibre. All are inferior to No. 1 in staple. Value Rs. 300.
10	Cambodia .	Grown at Cumbum, the cotton has much deteriorated both in colour and staple. The fibre is variable. We compare it with Westerns, and Good Westerns at Rs. 265. We value the sample at Rs. 260.
11	Do. .	Grown at Samalkot, it resembles Kumpta and find it equal to No. 1, only slightly inferior in colour. Value Rs. 305.
12 to 18	Selected . .	They equal the best class of Westerns. No. 12 has a slightly reddish tint, but is better in staple. Nos. 17 and 18 are slightly inferior in staple. With Westerns at Rs. 265, we value No. 12 at Rs. 275, Nos. 13 to 16 at Rs. 270, and Nos. 17 and 18 at Rs. 265.
19	Broach . .	Grown on Bellary soil, it has deteriorated and has adapted itself to the characteristic of the soil and has changed into Westerns. We value it at Rs. 270, say Rs. 5 better than ordinary Westerns.
20 and 21	Lalio and Kanvi	Grown on Bellary soil, both have deteriorated and have taken the appearance of Westerns. We value them at the price of Westerns, say Rs. 265.
22	Kumpta . .	The Bellary soil destroys the originality of an exotic and forces it to adapt itself to the soil and condition of the district. Kumpta, too, looks like Westerns, but the length of the Kumpta staple is maintained, hence we value it Rs. 10 better than Westerns, say Rs. 275.
23	Black-seed, Western.	The best indigenous cotton both in colour and length of fibre. Value Rs. 275.
24	Surat Broach .	Compared with No. 19 it has not deteriorated on Bellary soil as the seed was recently imported. Value Rs. 280.
25 and 26	Surat Kanvi and Lalio.	Compared with Nos. 20 and 21 they show less deterioration because the seeds are comparatively new. Value Rs. 270.
27	Broach Hagari	Compared with No. 24 it is slightly longer in length of fibre and we value it Rs. 5 higher, say Rs. 285.

In forwarding this report I ventured to suggest the following recommendations :—

Nandyal (1 to 9 of my numbers).—All are worth experimenting with on a large scale to test their actual production and ginning percentage. They are 10 to 20 per cent.

superior to Kumpta and 30 to 40 per cent. to Westerns, so that a decided step in improvement has already been taken. Nos. 2, 6, 7 should be abandoned on account of their low percentage.

Hagari.—The value of the selections Nos. 12 to 16 is equal to that of the best class of Westerns. Those which show a further falling off in the ginning percentage this year should be given up. No. 17 might be given another chance, but a low price accompanied by a falling percentage is against 18.

Of No. 23, the black seeded cotton, Messrs. Tata, Sons say it is the best indigenous cotton (of these samples) both in colour and length of fibre. The ginning percentage is so low that the production would have to be high before the crop would pay to grow. As its quality is so highly spoken of, experiments with it should be persevered in as the percentage might improve.

Looking at the results of experiments conducted for several years with 3 types of Guzerat cottons, it is obvious that only Broach should be maintained and *Kanvi* and *Lalio* abandoned as they are of an inferior type. The result of the acclimatization of these is that they have adopted the characteristics of their new locality. Cotton from recently introduced seed is superior in price and ginning percentage, but without figures of production on a field scale it is impossible to say further than this.

But, granting that these are also superior, it would be the safest policy to bring in annually a large proportion—say 30 per cent.—of freshly introduced Broach seed into the cotton districts supplied by the seed farm at Hagari. We recommend that this seed should be obtained from the Experimental Farm at Surat.

The long growing season of the Guzerat varieties is perhaps the most vital objection to their introduction unless it be found possible to sow earlier as is done in the case of Broach cotton in the Dharwar District.

Koilpatti Farm.—The following are the valuations furnished by Messrs. Tata, Sons & Co. and the Chamber of Commerce, Bombay :—

Valuations.

Serial No.	Corresponding pedigree No. of the Koilpatti Farm during 1911-12.	Valuation by Messrs. Tata, Sons & Co., Bombay, on 19th December 1912.	Valuation by the Chamber of Commerce, Bombay, 8th February 1913.
		Karunganni A type—Single Plant Selection.	
1	24	Out of the 17 samples examined, we find Nos. 1, 11, 12, 13, 14 and 16 superior to the average type of F. G. F. Tinnevelly cotton, especially in length of staple. We value them Rs. 25 higher than the price of F. G. F. Tinnevelly. The rest of the samples show a slight superiority over the average F. G. F. Tinnevelly and we value them Rs. 10 higher.	Samples 11 and 12 considerably superior to any other. Value about Rs. 370 per candy of 784 lbs. (if available in quantities) with fully good fair Tinnevelly at Rs. 328.
2	2		
3	1		
4	22		
5	17		Nos. 13 and 14 second best, about Rs. 30 per 784 lbs. over fully good fair Tinnevelly.
6	16		
7	15		
8	3		
9	6		Nos. 1, 6 and 3. Value about Rs. 25 above fully good fair Tinnevelly.
10	5		
11	8		
12	7		
13	14		Nos. 2, 4, 5, 7, 8, 9 and 10. Value about Rs. 15 above fully good fair Tinnevelly.
14	13		
15	12		
16	11		
17	10		Nos. 15, 16 and 17 somewhat better in staple than the 2—10 series, but lower in class. Value about Rs. 10 above fully good fair Tinnevelly.
		Karunganni C type—Single Plant Selection.	
1	1	The colour of these samples is not so bright as that of A type. It shows a tinge of red and is creamy white. In appearance, feel and length of staple, it is equal to average F. G. F. Tinnevelly and we value it at the price of F. G. F. Tinnevelly cotton.	All samples have a reddish tinge. Nos. 2, 3 and 5 are somewhat better in staple than fully good fair Tinnevelly and perhaps slightly higher in value. Remaining samples are of about the same value as fully good fair Tinnevelly. All samples show a rather rough fibre.
2	2		
3	3		
4	5		
5	6		
6	7		
7	8		

Valuations—contd.

Serial No.	Corresponding pedigree No. of the Koilpatti Farm during 1911-12.	Valuation by Messrs. Tata, Sons & Co., Bombay, on 19th December 1912.	Valuation by the Chamber of Commerce, Bombay, 8th February 1913.
		Karunganni A-C types—Under Field Scale.	
1	1 F. P.	Except Nos. 2 and 3, the other six samples are equal to ordinary F.G.F. Tinnevelly and we value them at the price of that cotton. Nos. 2 and 3 are decidedly better in appearance and length of staple and may be valued at Rs. 15 over the price of average F. G. F. Tinnevelly cotton.	We consider Nos. 6 and 8 the best on account of staple and value such cotton about Rs. 15 higher than fully good fair Tinnevelly. Nos. 4 and 7 we consider second best and about Rs. 10 higher than fully good fair Tinnevelly. Nos. 2, 3 and 5 are about equal to fully good fair Tinnevelly and No. 1 not up to fully good fair Tinnevelly.
2	1 F. C.		
3	1 F. C.		
4	2 F. P.		
5	2 F. C.		
6	3 F. C.		
7	3 F. P.		
8	4 F. P.		
		Basis.—F. G. F. Tinnevelly equal to Rs. 328 per candy of 784 lbs. laid down in Bombay.	*Basis.*—Fine Broach M. Gd. Rs. 330. Good Kumpta M. Gd. Rs. 335. Fine Navasari M. Gd. Rs. 360.

The work of this station is confined to the improvement of *Karunganni* which previously existed as a mixture in the fields with an inferior variety called *Uppam*. The valuations show that considerable progress has been made. My assistant, Mr. D. P. Mankad, who visited this locality last year, says that in Duraswamipura village, about 4 miles from the Koilpatti Farm, cultivators have been growing a *neglectum* mixture which they call *Pulichi paratti*. It is very important that the Department should take steps to check the introduction of such inferior varieties into this tract. The cultivators consider that the chief advantage of *Uppam* as compared with *Karunganni* lies in its shorter growing season, greater uniformity in ripening and superior hardiness.

Mr. Mankad has the following remarks on the cultivation of Cambodia cotton in Madras and these throw light on the causes which have led to the loss of reputation of this staple.

" During the past few years the cultivation of Cambodia in the Madras Presidency flourished remarkably well in garden soils commanded by well irrigation. The lands then were well ploughed and the cultivators paid special attention to its cultivation, including manuring, etc. Now-a-days, however, any land is put out under this cotton and the methods of cultivation are rough and ready.

" All the fields under Cambodia were found to contain plants of *Uppam* and *Karunganni* types to a considerable extent. It is this admixture of inferior Madras cottons which has been noticed by the trade and has rendered Madras Cambodia unsaleable as high class cotton. This admixture not only tells upon the ginning percentage, but also on the quality of the fibre which is of vital importance in the trade.

" If some steps are not immediately taken to keep Cambodia *kapas* perfectly pure from local *kapas*, the present state of affairs will become still worse and this high grade cotton will fall permanently to the level of the local cottons in price."

(*f*) *Bombay.—Dharwar and Gadag Experimental Stations.*—I supplied the following report on my inspection of the stations :—

1. *Dharwar Farm, 14th March 1913.*

(1) There is a series of nine generations of Broach cotton showing a continuous deterioration to the Kumpta or local type. We agreed that the most practical method of maintaining the Broach character would be to renew the seed over the whole area once every three years.

(2) In *Kumpta* selections, quantity should not be lost sight of. A particularly good strain seems to be grown in the Sangli State and seed from this locality should be tried against that locally produced.

(3) *Cambodia* is not suitable for Dharwar conditions.

(4) Cross between *Kumpta* and *Comilla.*—If possible, plants with the *Comilla* leaf should be selected

so that, in the event of this strain coming into cultivation, mixtures with local Kumpta could be easily detected.

(5) The crosses between Soft Peruvian and Cambodia are promising. It is recommended that first selections should be reduced to one plant of each type.

(6) *Selected Kumpta.*—The seed of this has not yet been distributed. An attempt should be made to ascertain the actual opinion of the cultivators on its merits. If they consider it superior they should show their appreciation by offering a higher rate for the seed.

(7) *68E—Cambodia (plant 24, selection).*—The plants are vigorous but the bolls are small and do not open properly. It is recommended to continue the trial of this at Gadag where conditions are more suitable for Cambodia.

(8) The results of manurial experiments are still inconclusive.

(9) *Wind-break experiments.*—The *Shevri* will probably last for three or four years without renewal.

(10) There is general dissatisfaction regarding the quality of the introduced Navasari seed. It would be as well to depute a special officer to select seed on the spot, and the extra expense incurred could be met by a proportional enhancement in the price of seeds sold to cultivators. Your own suggestion to obtain seed of the superior strain distributed from Surat is probably a still better way out of the difficulty.

2. *Gadag Farm, 15th March 1913.*

(1) This farm might be restricted to trials with American types of cotton. One-half of the seed of each of the selected plants of Cambodia-Soft Peruvian should be tried here.

(2) It would simplify matters a great deal if the whole of the Cambodia was treated as being essentially one variety so that material for selection could be taken this year over the whole experimental area. This year's field results are rather disappointing and disquieting, but it is to be hoped that the cultivators will agree to give Cambodia a further trial and they ought to be warned that fraudulent mixing with Dharwar American will not go to serve their best interests in the market.

(3) There are two forms of Dharwar American mixed in the fields. I would suggest that one plot of each should be grown for comparison. I should also like to have a sample of the cotton from each for expert valuation this season. I am satisfied in my own mind that the alleged deterioration of Dharwar American is caused by the mixture of a superior and inferior type.

(4) Two of the crosses appear to be promising : Christopher and Christopher, and Culpepper and Christopher. The cottons of these should be submitted for valuation.

(5) The histories of the various cottons under trial in the Southern Mahratta Country have been carefully and intelligently kept up and they now possess a distinctly appreciable value.

Valuations furnished by Messrs. Tata, Sons & Co. on the samples from Dharwar and Gadag Farms, on the 29th May 1913.

Serial No.	Remarks.
	Samples of the Dharwar Farm, 1911-12 crop.
1	Kumpta ordinary. Value Rs. 290.
2	Kumpta Cross. This is an excellent cotton and shows much improvement in colour, staple and strength of fibre. In spinning quality we consider this cotton in no way inferior to indigenous Navasari cotton, only it lacks the soft silky feel and the creamy lustre of Navasari, hence we value it at Rs. 325. Of the five samples this is by far the best.

Valuations furnished by Messrs. Tata, Sons & Co. on the samples from Dharwar and Gadag Farms, on the 29th May 1913—contd.

Serial No.	Remarks.
3	Broach (new seed from Navasari). Grown on Dharwar Farm, this cotton has picked up some of the characteristics of the soil and climate. Being Navasari seed it is superior to Sawginned Dharwar and Kumpta, but it has deteriorated in the Dharwar soil from its original quality as grown in Navasari. This is owing, perhaps, to the high altitude and dry climate of Dharwar. We have marked that whenever Navasari has been removed further away from the sea it shows deterioration. We value this sample at Rs. 315.
4	Cambodia. Though superior to Kumpta and Dharwar it has lost its native lustre and strength of fibre and has deteriorated considerably on the Dharwar Farm. Value Rs. 300.
5	Kumpta x Ghogari. This cross is far superior to ordinary Kumpta, but it is inferior to No. 2 Cross. Value Rs. 315.
6	Kumpta ordinary. Slightly inferior to No. 1. Value Rs. 288.
7	Kumpta selected for quality. It shows improvement in colour over No. 6. Value Rs. 298.
8	Kumpta selected for quantity. It is inferior to ordinary Kumpta. Value Rs. 285.
9	Kumpta Cross. It shows improvement over Nos. 6, 7 and 8, but compared with No. 2, it shows considerable falling off in colour and length of staple. Value Rs. 305.
10	Broach old seed. It has lost all its characteristics of Broach and has deteriorated to the level of Kumpta, and we value it at Rs. 300. There can be no comparison between this and No. 3, as the latter retains its character of Broach cotton, while No. 10 has entirely lost it.
11	Kumpta x Ghogari. Compared with No. 5 it shows a slight falling off. This we attribute to No. 5, being crossed on the Surat and No. 11 on the Dharwar Farm. Value Rs. 310.
	Samples from Gadag Farm, 1911-12 crop.
12 to 17	Samples from Gadag Farm. These 6 samples are more or less alike and of the characteristic of Sawginned Dharwar cotton. No. 14 being machine ginned (not sawginned), shows better length of fibre over the rest which are sawginned. All the 6 samples show variations. We value Nos. 14 and 16 at Rs. 300 and the rest at Rs. 295.
18 and 19	Of the two, No. 18 is better in length of staple; both the samples are superior to Kumpta or Dharwar ordinary. We value No. 18 at Rs. 305 and No. 19 at Rs. 295. (No. 18, Dharwar American type; and No. 19, New Orleans type of 1912-13 crop.)

Basis of prices—	Rs.
Good Sawginned Dharwar	288
Good Kumpta Ginned	290
Fine Broach Ginned	290
Good Northerns Ginned	295
Good Cambodia Ginned	320
Fine Navasari Ginned	340

In forwarding this report I submitted the following supplementary observations :—

Dharwar Farm.—We agreed that in the series of 9 generations of Broach cotton it showed a continuous deterioration to the Kumpta or the local type and that the most practical method of maintaining the Broach character would be to renew the seed over the whole area once every three years. Messrs. Tata state as follows regarding a sample of cotton grown from Broach new seed from Navasari :—

> " This cotton has picked up some of the characteristics of the soil and the climate. Being Navasari seed it is superior to sawginned Dharwar and Kumpta, but it has deteriorated in the Dharwar soil from its original quality as grown in Navasari. This is owing, perhaps, to the high altitude and dry climate of Dharwar. We have marked that whenever Navasari has been removed further away from the sea it shows deterioration. We value this sample at Rs. 315 against Navasari Rs. 340."

On a sample of cotton of Broach cotton from old seed (acclimatized seed) the remark is as follows :—

> " It has lost all its characteristics of Broach and has deteriorated to the level of Kumpta and we value it at Rs. 300. There can be no comparison between this and Broach cotton from new seed as the latter retains its character of Broach cotton, while the former has entirely lost it. This has been valued at Rs. 300 while Broach from new seed valued at Rs. 315 and original Navasari at Rs. 340."

In the Kumpta selections we agreed that quantity should not be lost sight of. The sample from a plot grown with this object in view was valued at Rs. 285 while a sample of ordinary Kumpta was valued at Rs. 288 and another at Rs. 290; while a sample of Kumpta selected for quality was valued at Rs. 298; while of the special selections the

Kumpta Cross No. 1339 from one plot was valued at Rs. 325 and from another at Rs. 305, the market price of the good Kumpta ginned of the day being Rs. 290.

Of the Kumpta Cross, which is the best cotton on the Dharwar Farm, Messrs. Tata have the following remarks :—

> " This is an excellent cotton and shows much improvement in colour, staple and strength of fibre. In spinning quality we consider this cotton in no way inferior to indigenous Navasari cotton; only it lacks the soft silky feel and the creamy lustre of Navasari, hence we value it at Rs. 325."

Of the second sample of the Kumpta Cross cotton they say that when compared with No. 1 it shows considerable falling off in colour and length of staple; the valuation is Rs. 305. The discrepancy in the quality is puzzling, but it may be capable of explanation.

Anyhow, valuations indicate that Kumpta Cross 1339 should be persevered with.

We decided that Cambodia is not suitable for Dharwar conditions and Messrs. Tata's opinion confirms this as they say :—

> " That though superior to Kumpta and Dharwar it has lost its native lustre and strength of fibre and has deteriorated considerably on the Dharwar Farm. It is valued at Rs. 300 against good Cambodia ginned Rs. 320."

Of the Kumpta and the Ghogari Crosses 1027A and 1364, Messrs. Tata say of the former that it is far superior to ordinary Kumpta but it is inferior to the Kumpta Cross 1339 and that the latter shows a slight falling off. The first is valued at Rs. 315 and the second at Rs. 310.

Gadag Farm.—We considered that it will simplify matters a great deal if the whole of Cambodia was treated as being essentially one variety, and this decision is con-

firmed by the remarks on the six samples made by Messrs. Tata :—

> "That they were all more or less alike and of the characteristics of sawginned Dharwar cotton The machine ginned sample shows better length of fibre over the rest which are sawginned. Two samples, Cambodia 102E and 67E, valued at Rs. 300 and the rest at Rs. 295 against Rs. 288 of good sawginned Dharwar and Rs. 320 good Cambodia ginned."

In conclusion, with reference to my statement that alleged deterioration of the Dharwar American cotton is caused by the mixture of an Upland and the New Orleans type of cotton, it seems that I am so far correct as Messrs. Tata value the former at Rs. 305 and the latter at Rs. 295. I hope that this year one full plot under each will be grown for comparison.

As regards the Cambodia cotton experiments which have been conducted in this tract, 3,500 acres were sown during the past year. Continuous rain during the seedling stage caused so much wilt that many plants died. The shoot borer would not allow the plants to grow until very late. The continuous east winds for six months (which is considered bad for cotton) caused many flower buds to drop and the soil moisture was quickly evaporated. The result of these adverse circumstances was that the yield was lowered by 40 per cent., that is, the yield should have been 350 to 375 lbs. per acre instead of about 210 lbs. The ginning percentage varied from 38 to 32·5 with a general average of 36·1.

The prices per *Naga* of 1,344 lbs. realized at the auction were Rs. 185 to Rs. 161, the quotations for Dharwar American and Kumpta on the same day being respectively Rs. 140 and Rs. 139 to Rs. 141.

Surat.—A set of samples from this station shows that the product has now become so uniform that there is only a difference of Rs. 13 per candy between the highest and lowest quotations.

Dohad.—Samples of *Bhuri* and Cambodia produced at this station were valued at Rs. 310, fine Broach of the day standing at Rs. 300. *Bhuri* yielded 1,104 lbs. seed cotton per acre, ginning percentage 32·8; Cambodia 876 lbs. per acre, ginning percentage 32·3. Early sown *Varhadi* yielded at the rate of 884 lbs. per acre, while the same late sown was cut off by frost. It will be seen, however, from the following remarks, that there is small prospect of extension of cotton cultivation in the Panch Mahals. The soils in which *Bhuri* and Cambodia were tried grow wheat in these parts. Panch Mahals does not grow much cotton, a portion from Derol to Pawagarh grows *Kanvi* and *Ghogari*, the latter predominating. Cottons come to maturity earlier in these parts owing to the stony nature of the soil. Kalol Taluka grows *Rozi* and *Kanvi* to a certain extent. Beyond this the cultivation of cotton practically ceases. It does not seem that the cultivation of cotton will spread, as the soil capable of producing cotton will yield two crops, namely, maize and gram, or groundnut and wheat.

Nadiad.—I submitted the following remarks on the samples sent by this station :—

Judging from the valuations of the cottons from Nadiad, Cambodia is easily first, but as this is a new introduction, some time must elapse before it can be confidently recommended for general cultivation under irrigation.

The claims of *Lalio* cotton indigenous to the tract should be carefully tested. It is highly probable that ultimately it would be found the most profitable to grow.

Bourbon is valued highly but its perennial nature is objectionable. Experiments made years ago certainly proved that it is not a reliable plant to depend upon. Mr. Spence's attempts at its cultivation on a large scale at Deesa and Jamnagar both signally failed and no one reports even moderate success with it. For all practical purposses the cotton experiments at Nadiad could be confined to trials with Cambodia and *Lalio.*

Valuations by Messrs. Tata, Sons & Co. on the six samples of Nadiad on 23rd June 1913.

Serial No.	Name of variety.	Remarks.
1	Cambodia .	Nadiad Farm appears to suit this cotton as all the characteristics of Cambodia are maintained. We value it at Rs. 320. We recommend that special attention should be given to its cultivation at Nadiad.
2	Bhuri . .	This cotton is after the style of Ghat Berars and we class it equal to Kirkeli. Value Rs. 300.
3	Lalio . .	The Nadiad soil suits the seed as the sample under inspection equals the best cotton grown in Bawla (Guzerat District). Value Rs. 290.
4	10 T. Bourbon	It is a very nice cotton, silky and long stapled, and is equal to some low grades of Egyptian cotton. We value it at Rs. 350.
5	Varhadi . .	This cotton has entirely changed its character and looks more like short staple Rajputana Bengal than like Khandesh. Value Rs. 250.
6	Comilla × Bani	This cross shows the roughness and feel of Comilla (Assam) combined with the staple of Bani. It can be compared to Fine Warora. Value Rs. 300.

Basis of value—

	Rs.
Low Egyptian	350
Fine Surat	330
Kirkeli	310
Fine Warora	300
„ Ghat (Chikli)	278
„ Bengal	245
„ Navasari	345
Cambodia	320
Fine Broach	305
„ Guzerat	290
„ Akola	268

At Bawla in the Ahmedabad District, Mr. Mankad reported as follows :—

" Four persons tested Cambodia on the following areas :—

Area in acres.	Total outturn in lbs.	Outturn per acre.	Valuation realised per 40 lbs. kapas.	Remarks.
			Rs. A. P.	
0-24	680	1,133	6 6 0	Irrigated five times.
0-30	1,000	1,333	6 5 3	Irrigated three times.
1-0	800	800	6 4 0	Irrigated two times.
1-0	400	400	6 6 0	White-ants damaged crops. No watering given.

All the Cambodia was purchased by one man who gave ordinarily four annas more per maund over the local cotton *Lalio*."

There is a tendency for the cultivators to extend the cultivation of Cambodia next year. I learn that cultivators are willing to pay high rates for the seed, as much as Rs. 5 for 40 lbs. seed. It was also said that some seed was sold at Rs. 8 a maund of 40 lbs.

With regard to the results of *Lalio*, it must be said that, under the same condition (irrigation), one acre and seven gunthas yielded 2,000 lbs. *kapas*, that is, 1,700 lbs. per acre. The possibilities of *Lalio* should be very carefully tested as present indications point to its being quite able to hold its own ground against Cambodia.

The cultivators at Bawla are, however, in favour of their local cotton—*Lalio*, and think that though the results are promising the new cotton, Cambodia, is a much more delicate variety than their local cotton. They are also aware of the fact that it would be susceptible to frost and insect pests.

To conclude with Guzerat, I quote the general remarks submitted to the Director.

" 1. *Surat.*—There are three strains maintained for seed distribution. The Syndicate have agreed to buy the produce of these at 5 per cent. over local prices and I am informed that private firms are independently offering 6

per cent. As this is the second season in which the improved cottons will be on the market it is gratifying to learn that the traders appreciate the value of the selections.

" 2. *Broach.*—The tendency of the cultivators in this tract is to mix *Ghogari* with Broach in order to help out the ginning percentage of the latter. Some of the lighter soils might be devoted to the culture of pure *Ghogari*, but this point will be the subject of further enquiry. Broach cotton seed, obtained from Surat, was distributed by the local Agricultural Association. The members of this body have apparently not supervised the tests so closely as they require and they are only now invoking the aid of the Agricultural Department, as they foresee the difficulty of disposing of their produce on favourable terms without some support in the shape of an official guarantee. They may find a way out, but in the event of an expansion in their task of cotton seed distribution it would be as well to warn the Association to be guided by the advice of your Department. As you remarked, these Associations under proper control may become valuable agencies for the distribution and maintenance of selected crops. The Association ought soon to be strong enough to employ an expert staff to assist them in their operations. Wilt is said to be increasing in this district and is probably due to the continuous cropping of the land under cotton. I understand that the Imperial Mycologist has taken up the investigation of this disease.

" 3. *Nadiad.*—Our long-cherished hope that some tree cottons could be profitably grown in the Kaira District has been dispelled.

Bourbon is too uncertain, as it is likely to do badly in wet years and, being a perennial crop, the land on which it grows, under the careless methods of the cultivators, becomes a jungle of weeds. It also acts as an agent in the propagation of boll worm. Cambodia and *Bhuri* both promise very well, if slight irrigation (which is available in many places) can be given them at the start. The claims of the local *Lalio* are strong and are being seriously considered.

"4. *Baroda.*—The experiments here are identical with those at Nadiad. There is a possibility that in this tract *Bhuri* can be grown as a dry crop. I pointed out on the spot that the Cambodia grown from Madras seed was contaminated with an admixture of *Uppam* and *Karunganni*. The plots at Nadiad had been of course purified by the Superintendent and I suggested that you instruct your Department in the Southern Mahratta Country to see that their fields were also purged of this annoying mixture.

"5. *Dohad.*—Cambodia, *Bhuri* and *Varhadi* (*roseum*) were doing exceedingly well, but it seems waste of time to distribute good cotton seed amongst such bad cultivators. However, the good example shown them at the Dohad Farm may show fruit in due time."

The Chief Karbhari, Rajkot State, sent in the following report on the crops resulting from 50 lbs. *Varhadi* and 20 lbs. Cambodia seed, which were sent to him for trial. The outturn of *Varhadi kapas* was $17\frac{1}{2}$ maunds in 2 *bighas* of the palace garden experimented upon, or in other words it was 21 maunds and 35 lbs. per acre (875 lbs. *kapas* per acre); whereas that of Cambodia *kapas* was $2\frac{1}{4}$ maunds in $\frac{1}{2}$ acre of it, *i.e.*, $4\frac{1}{2}$ maunds per acre, a maund being equal to 40 lbs.

The ginning percentage eventuated in 40 per cent. of *Varhadi* and 35 per cent. of Cambodia cotton.

The result is more in favour of *Varhadi* than Cambodia which does not, it seems, suit the soil. The *Varhadi* is being grown on a larger scale this season.

Valuation by Messrs. Tata, Sons & Co., Bombay, on the samples from Rajkot on 23rd June 1913.

Serial No.	Name of variety.	Remarks.
1	Varhadi . .	This cotton has preserved all its characteristics of Akola except the staple which shows deterioration. Value Rs. 260.
2	Cambodia .	The cotton has deteriorated all round and looks more like Ghat cotton (Chikli). Value Rs. 270.

Basis of valuation—

	Rs.
Fine Warora	300
„ Ghat (Chikli)	278
„ Akola	268
Mathio	250

Dhulia.—Messrs. Tata were good enough to supply the following valuations and remarks on the samples sent from this station (10th April 1913) :—

Serial No.	Name of variety.	Remarks.
1	Rosea . .	It has all the characteristics of Fine Khandesh cotton, only it is slightly better in staple than the usual run of Khandesh cotton for which we value it Rs. 8 higher than Fine Khandesh (basis Fine Khandesh, Rs. 272), say Rs. 280 per candy.
2	Cutchica	No improvement, practically Fine Khandesh. Value Rs. 272, being the basis of Fine Khandesh.
3	Vera . .	It has lost its Khandesh characteristics and has the colour, staple and feel of Bani Berars. Taking Rs. 320 as the basis of Bani Akola, we value it the same price, Rs. 320 per candy.
4	Malvensis .	It is like No. 1. The feel, however, is better, which advantage is counterbalanced by the staple being slightly inferior. We value it at Rs. 5 more than Fine Khandesh (basis Rs. 272), say Rs. 277 per candy.
5	Khandesh Jari	It is ordinary fully Good Khandesh cotton. Value Rs. 262 (same as fully Good Khandesh, basis of Rs. 262).
6	Bani . .	It is equal to No. 3 and of the same value, say Rs. 320 per candy.
7	Comilla . .	In the Khandesh soil and climate it has slightly lost its native harshness; in all other respects it remains Assam cotton. We value it at Rs. 275 per candy, say Rs. 15 better than Superfine Bengal (basis Superfine Bengal, Rs. 260).

Valuations.—All samples received were submitted to Messrs. Tata, Sons & Co., Bombay, for valuation, and cordial acknowledgment is due to them for their kindness and promptitude in giving opinions on cottons whenever submitted to them.

Samples of the Koilpatti Agricultural Station were reported upon by the Bombay Chamber of Commerce to whom thanks are also due.

III.—Programme of work for 1913-14.

(1) To visit and advise on points regarding cotton and its cultivation whenever requested to do so by Provincial Departments of Agriculture.

(2) By special invitation of the Departments of Agriculture of the United Provinces of Agra and Oudh, Bombay, and North-West Frontier Province to report on the work done in the way of cotton improvement in those provinces.

(3) The question of the distribution of seeds of promising varieties will be further discussed with the proper authorities in the United Provinces, Central Provinces, Bombay and the Punjab.

(4) The study of the behaviour of *Bhuri* and Cambodia and other such cottons in non-cotton-producing tracts will be continued.

(5) An enquiry on the manurial requirement of cotton will be continued.

(6) Researches on the botany of cotton will be continued.

REPORT

OF THE

Agricultural Research Institute and College, Pusa

(Including the Report of the Imperial Cotton Specialist)

1913-14

CALCUTTA
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Report of the Agricultural Research Institute and College, Pusa,

(Including the Report of the Imperial Cotton Specialist)

1913-14.

REPORT OF THE DIRECTOR.

(BERNARD COVENTRY, C.I.E.)

I.—CHARGE AND STAFF.

Charge.—Mr. J. Mackenna, M.A., I.C.S., held charge of the office of Agricultural Adviser to the Government of India and Director, Agricultural Research Institute, Pusa, till my return from leave on the 23rd February 1914, when I resumed charge of the post.

Mr. A. C. Dobbs held the post of Assistant to the Agricultural Adviser to the Government of India till 28th April 1914, when he was appointed to act as Imperial Agriculturist and Mr. M. Wynne Sayer, B.A., who joined the Department on the 20th March 1914, was appointed to officiate for Mr. Dobbs.

Staff.—The Chemical Section remained in charge of Dr. J. W. Leather, V.D., Ph.D., F.I.C., throughout the year.

Mr. H. E. Annett, B.Sc., F.C.S., F.I.C., Supernumerary Agricultural Chemist, returned from study leave on 28th November 1913, and was appointed Agricultural Chemist to the Government of Bengal on 1st January 1914. Mr. Jatindranath Sen, M.A., F.C.S., First Assistant in the Chemical Section, was appointed Supernumerary Agricultural Chemist on the 9th February 1914.

Mr. A. Howard, M.A., A.R.C.S., F.L.S., Imperial Economic Botanist, and Mrs. Howard, M.A., his Personal Assistant, returned from leave on 19th October 1913. As

in previous years Mr. and Mrs. Howard proceeded to Quetta in May 1914, and will stay there for five months for work in connection with the development of the fruit industry in Baluchistan. During the year under report Mr. Howard was appointed a Companion of the Most Eminent Order of the Indian Empire.

The Mycological Section was in charge of Dr. E. J. Butler, M.B., F.L.S., till the 28th March 1914, when he proceeded on nine months' combined leave.

Mr. F. J. F. Shaw, B.Sc., A.R.C.S., F.L.S., on the termination of his appointment as Officiating Government Mycologist, Madras, resumed his duties at Pusa as Supernumerary Mycologist on the 5th November 1913. He has been appointed to officiate as Imperial Mycologist during Dr. Butler's absence on leave.

Mr. T. Bainbrigge Fletcher, R.N., F.E.S., F.Z.S., joined the post of Imperial Entomologist on 1st December 1913. Previous to his appointment Mr. A. J. Grove, M.Sc., Supernumerary Entomologist, held charge of the Entomological Section. Mr. Grove has been deputed to the Punjab since 28th January 1914, to carry out work on grain pests and cotton bollworm.

Mr. F. M. Howlett, B.A., F.E.S., remained in charge of the Pathological Entomological Section throughout the year.

The Bacteriological Section was in charge of Mr. C. M. Hutchinson, B.A., during the whole year, except for a short period of two weeks from 24th February 1914, when he was on privilege leave and Mr. J. H. Walton, B.A., B.Sc., Supernumerary Agricultural Bacteriologist, officiated for him.

The Agricultural Section was in charge of Mr. S. Milligan, M.A., B.Sc., till 28th April 1914, when he proceeded on one year's combined leave and Mr. A. C. Dobbs took over charge from him.

The number of Supernumerary Agricultural appointments was reduced from three to two during the year under report. Mr. N. S. McGowan, Dip. in Agri. (Cantab.), and Mr. T. Gilbert, B.A., Dip. in Agri. (Cantab.), have been

appointed Deputy Directors of Agriculture in Bihar and Orissa and Bombay respectively. The two Supernumerary posts are now held by Mr. G. D. Mehta, L.Ag., B.A., N.D.A., N.D.D., who has been posted to Madras for training, and Mr. M. Wynne Sayer, B.A., who joined the Department on 20th March 1914.

II.—Work of the Institute.

Scientific Work.—An account of the scientific work of the Institute during the year is given in the reports of the several sections.

Training.—The training of students in post-graduate courses was continued and short courses were also given in Cattle management and Sericulture.

Four students were under training in Agricultural Chemistry during the year under report. The two students referred to in the last year's report, *viz.*, a private student from Madras and a Government Stipendiary from the Travancore State, completed their training. A private student who was studying for the D.Sc. degree of the Allahabad University worked on a piece of research for eight months in the Chemical Laboratory. A student deputed by the Department of Agriculture, Central Provinces, for training in Agricultural Bacteriology was given a preliminary course of training in Agricultural Chemistry.

In the Entomological Section the student deputed by the Department of Agriculture, Travancore, and the student deputed by the Assam Department of Agriculture referred to in the last year's report completed their training in General Entomology during the year under report.

In the Bacteriological Section the probationary research assistant under the Agricultural Chemist to the Punjab Government who was deputed to this Institute for training continued his course in Agricultural Bacteriology during the year.

In the Agricultural Section a graduate of the Sabour Agricultural College deputed by the Bengal Department of Agriculture is undergoing training in General Agriculture.

Besides the regular students mentioned above, the following officers worked in the Mycological Laboratory during the year :—

Mr. A. C. Tunstall, Mycologist to the Indian Tea Association, for about a week, in September 1913.

Mr. G. H. Alington, I.F.S., Assistant to the Forest Botanist, in January 1914, in connection with tree diseases.

Mr. B. L. Gupta, B.Sc., Professor of Biology in the Reid Christian College, Lucknow, attended the Laboratory during May and June 1914, and received a course of lectures and practical work on the morphology of fungi.

During the year under report, seven students attended the short courses—one in " Cattle Management " and six in " Sericulture." Besides the regular students, three visitors were given practical instruction in sericulture and silk-dyeing.

III.—Publications.

The Agricultural Journal, Scientific Memoirs and Bulletins continued to be issued during the year. With a view to keep down the free distribution list and also to encourage Agricultural Associations, Co-operative Societies, students of Agricultural Colleges and Assistants in the Agricultural Departments, specially reduced rates of subscription for the Journal and Memoirs and Bulletins were sanctioned during the year. This has led to a substantial increase in the number of subscribers. With a view to economy steps were taken to supply persons and institutions on the free distribution list with reprints of articles on the special branches of agriculture and its allied sciences in which they are interested in lieu of the Journal. Arrangements were also made during the year for making the Department's publications available for sale at principal centres in various parts of the country.

The Department published during the year 16 Memoirs and 7 Bulletins. In the Veterinary Series of Memoirs

started in April 1912 no less than 8 papers have been published during the course of two years and the number promises to increase in the near future. As regards other series of memoirs a good number of papers were published in the Botanical and Chemical Series to which the Provincial Departments have also contributed.

There is a steady increasing demand from the Indian public for Bulletins as they are mostly of practical interest. As a result Bulletin Nos. 28 and 29 on Lac and Eri silk culture have been reprinted and the Government of India have authorised the Agricultural Adviser to increase in future to 2,000 copies bulletins for which there is likely to be a good demand.

The grant for publications as at present sanctioned is Rs. 29,000. During the last two years greatest economy had to be exercised to keep the expenditure within the sanctioned grant. The rates both for letter-press printing and reproduction of illustrations have been recently revised. Papers received are also carefully scrutinised and all illustrations not absolutely required are eliminated. But as the investigation of problems is yearly on the increase the volume of matter offered for publication is anticipated to become larger each year and it will soon be necessary to ask for a further addition to the grant.

IV.—General Administration.

Buildings and Works.—During the year under report the Government of India sanctioned the construction of eight additional quarters for the subordinate staff of the Institute. The extension of the Director's office building referred to in the last year's report was completed during the year. Proposals have been submitted to Government for the installation of electric lights and fans in the European bungalows and the Guest House at Pusa, and for the addition of a Female Ward to the Pusa Hospital.

Library.—The third edition of the catalogue of the library is in the press and will shortly be out. During the year under report over 500 volumes have been added by purchase besides several foreign bulletins, memoirs, reports,

etc., which are received in exchange from different parts of the world.

Pusa Middle English School.—The Pusa Middle English School which was established in 1912 is becoming popular. It has four English and four Vernacular classes and the total number of boys on the roll is 93 out of which 53 belong to the Estate and the remaining 40 come from the neighbouring villages. The school is located temporarily in the Students' Hostel until the completion of the school building which is under construction. Proposals for raising the present school to the status of a High School and also for the establishment of a Girls' School at Pusa are under the consideration of the Local Government.

General Health of the Station.—The general health of the station during the year under report was on the whole very good. Relief was afforded to 9,226 cases, of which 8,999 were treated in the out-patients' department and 227 admitted as in-door patients. One hundred and two cases amongst European officers and families were attended to. The daily average number of patients treated was 64·05 out-door, and 10·69 in-door.

Four deaths occurred in hospital, one from Gangrene-foot, one from Malarial Cachexia, one from Cirrhosis Liver and one from Suppurating Tonsilitis.

The number of Estate cases treated for Malarial Fever was small when compared with the admissions from the neighbouring villages. This was probably due to the Estate people willingly taking the quinine which was issued prophylactically towards the close of the monsoon. An epidemic of cholera which broke out in the villages in the immediate vicinity of Pusa, during the months of April, May and June, threatened to be a source of grave danger. Immediate and successful measures were taken to prevent it entering the Estate. Chief of these was keeping of the water supply pure by disinfecting and cleaning the wells. The epidemic was thus kept out of the Estate limits.

Two hundred and five surgical operations were performed of which nineteen were major, and one hundred and eighty-six minor.

Nine primary vaccinations and three re-vaccinations were performed during the early part of the year.

V.—Accounts.

The total expenditure during the financial year 1913-14 was Rs. 4,72,471 as under :—

	Rs.
Office of the Agricultural Adviser to the Government of India and Director of the Institute	2,14,158
Chemical Section	38,455
Mycological Section	37,388
Entomological Section	33,942
Pathological Entomological Section .	26,749
Botanical Section	27,854
Bacteriological Section . . .	29,171
Agricultural Section . . .	64,754
	4,72,471

The budget of the Agricultural Adviser for the year under report included a portion of the grant of Rs. 1,10,000 referred to in previous year's report for meeting the expenditure in connection with the engagement of Mr. W. Hulme as Sugar Engineer in the United Provinces for the development of the Indian Sugar Industry. The engagement of Mr. Hulme was sanctioned in the first instance, for three years from 1911-12. It has been decided to retain his services for a further period of two seasons and the expenditure during the current year will be met from the saving in the grant of Rs. 1,10,000 made for the purpose.

A sum of Rs. 15,000 was provided in the budget for payment to the Indian Tea Association as a grant-in-aid.

Out of the sum of Rs. 60,000 allotted during the year ending 31st March 1914, by the Government of India, for improvements connected with the Pusa Institute, Rs. 14,254 were transferred to the Public Works Department Budget for meeting the cost of extension of the Pusa Library and Rs. 25,000 paid towards purchase of steam cultivating machinery for the Pusa Farm. The balance was spent on

testing the milling and baking qualities of wheat, the bacteriological investigation of rice, the demonstration of improved methods of refining saltpetre, experiments with cotton and plant breeding by the Imperial Cotton Specialist, construction of a Potculture house for the Imperial Mycologist, an additional Laboratory for the Imperial Pathological Entomologist and the improvement of the drainage of the low-lying portions of the Pusa Estate.

The gross receipts during the year from the sale of farm produce, milk, publications of this Department and other articles, amounted to Rs. 22,157 as against Rs. 14,663 of the preceding year.

VI.—Visitors.

In response to the invitation of Mr. J. Mackenna, Lord Islington, Sir Valentine Chirol, Sir Theodore Morison, Messrs. Sly, Scott and Fisher of the Royal Commission on Public Services in India visited the Institute on the 17th January 1914.

During the year under report the Hon'ble Sir Robert Carlyle, K.C.S.I., C.I.E., I.C.S., Member-in-charge of the Department of Revenue and Agriculture, Government of India, the Hon'ble Sir Edward Maclagan, K.C.I.E., C.S.I., I.C.S., Officiating Revenue Member, the Hon'ble Mr. L. J. Kershaw, C.I.E., I.C.S., Secretary to the Government of India, Department of Revenue and Agriculture, Colonel E. H. Hazelton, F.R.C.V.S., A.V.S., Principal Veterinary Officer in India, Mr. M. J. Cogswell, Controller of Printing, Stationery and Stamps, Professor Wyndham R. Dunstan, M.A., LL.D., F.R.S., Director, Imperial Institute, London, Professor Brück of Griessen University, Germany, Mr. M. A. Yamada of the Agricultural Experiment Station, Formosa, Chev. Dr. G. Gorio, Consul for Italy, Bombay, and many others visited the Institute.

REPORT OF THE IMPERIAL AGRICULTURIST

(A. C. DOBBS, B.A.)

I.—ADMINISTRATION AND TOURS.

Charge.—Mr. Milligan held charge of the Pusa Farm for the first ten months of the period under review; he went home on long leave at the end of April, after which the writer officiated for him.

The number of Supernumerary Agricultural appointments was reduced from three to two during the year under report. Messrs. Gilbert and McGowan vacated their posts on the supernumerary establishment, on the creation of new appointments on the regular cadre in Bombay and Bihar, and one of the resulting vacancies was filled by the appointment of Mr. M. Wynne Sayer who arrived in India at the end of March, and is now officiating as Assistant to the Agricultural Adviser.

The other post vacated was absorbed in one of the new posts on the regular cadre, while the second remaining Supernumerary appointment continues to be held by Mr. G. D. Mehta, now working in Madras.

Mr. Judah Hyam was in charge of the Breeding Herd throughout the year.

Mr. Mohomed Ikramuddin held the post of 1st Farm Overseer during the year, in addition to the duties of the 2nd Farm Overseer from 16th May 1913 to 4th November 1913.

Mr. Arjan Singh, Agricultural Assistant, Lyallpur Farm, was posted to the vacant post of 2nd Farm Overseer on the 5th November 1913.

Training.—The following students attended the courses :—

1. Mr. B. M. Valweker, from Mysore State, in cattle management, from 29th January 1914 to 4th April 1914.

2. Mr. Kali Prosanna Roy was sent by the Bengal Government for agricultural training at Pusa.

Tours.—Mr. Milligan visited Dacca and Sabour Farms with the Officiating Agricultural Adviser to the Government of India, in August; and Poona, Bombay, Ahmedabad and Umballa to see dairies in September 1913. He also attended the meetings of the Board of Agriculture at Coimbatore in December 1913 and gave evidence before the Public Services Commission on behalf of the Imperial Department of Agriculture, at Bombay during February 1914.

II.—Farm Cultivation.

Character of the season.—The rains began with 7 inches in May 1913. The monsoon was characterised by well distributed rainfall throughout, with very heavy falls in June and August. The paddy crop was considerably damaged by floods owing to the defective draining of the Estate. Three-fourths of an inch of rain in the middle of October and again in the middle of December, ensured heavy *rabi* crops, which, however, suffered severely from a similar fall accompanied by strong wind in the middle of February.

Crop Experiments.—The experiments mentioned in last year's report have been continued.

Cultivation.—A Fowler's double engine steam cultivation tackle was obtained in September 1913 with a disc plough, cultivator, harrow, and roller.

The object of this new departure was not only the study of the economics of steam cultivation, but also to enable the Agriculturist to deal more effectively with the labour difficulties incidental to the intensive cultivation, by means of hired labour, of so large an area as is necessary to support the Pusa herd of Montgomery Cattle.

The farm is not an ideal one for steam cultivation, being intersected by public roads which cut it up into irregularly-shaped fields, but by taking the whole available area, squaring up some of the fields, and abandoning odd corners, it will be possible to eliminate most of the land that cannot be

ploughed by steam tackle and yet to leave a sufficient area to employ the tackle to the limit of its capacity. There will still, however, be some waste incurred in moving over considerable distances from field to field.

III.—Live-stock and Poultry.

Breeding Herd.—As may be inferred from the reference above to the herd of Montgomery cows, this herd has become the pivot on which the policy of the farm turns.

Started originally with the idea of preserving and typing the Montgomery breed, and incidentally providing the officials collected at Pusa with a pure milk supply, the herd has grown with the expansion of the Institute and the growing demand for milk from the large number of inhabitants of the estate,—until it has taxed the capacity of the farm to provide sufficient fodder for both the working bullocks and for the breeding herd.

A partial solution has been found in the purchase of the steam tackle, and it is proposed at the same time to grade up the milk producing power of the herd by crossing the poorest milkers with an Ayrshire bull.

The product of this cross has been demonstrated by the Military Dairies in Northern India to be exceedingly useful, the heifers giving milk in amounts comparable with those given by Ayrshire cows, while the bullocks make excellent work cattle.

There will therefore be maintained at Pusa, henceforth, two herds; one of selected milkers of the Montgomery breed; the other a herd of cross-bred Ayrshire-Montgomery cattle which will, it is hoped, take its part in a comprehensive scheme for improving the dairy cattle of India by cross breeding.

Should a considerable development of one or both of these breeds be justified later on, it will be possible to increase considerably the number of breeding cattle at Pusa, owing to the economy of fodder effected by the use of the steam tackle instead of bullocks for cultivation.

Sheep.—The advantage of crossing Dumba rams with the local sheep for the production of mutton having been demonstrated, breeding for mutton has been given up, and an attempt is being made to improve the wool of the local sheep by crossing with Merinos, as mentioned in last year's report.

Poultry.—In view of the general interest now evinced in poultry keeping in the Provinces it has been decided to limit the functions of Pusa to the importation of pure bred birds to maintain the breeds kept on Provincial farms. The Assistant to the Agricultural Adviser to the Government of India is in touch with breeders at home and is prepared to give his advice or assistance to intending importers. No poultry are now kept at the Pusa Farm.

IV.—General.

All the available farm land has been brought under cultivation.

Manuring with superphosphate has become part of the routine practice of the farm as a result of the proof of the economic value of that manure in the experimental plots.

Considerably better crops have been obtained in recent years and with the high cultivation now rendered possible an economic necessity is beginning to appear of growing more valuable crops, or varieties with sufficient strength of root and stem to support a higher yield than any obtainable from the varieties now available.

V.—Programme of work for 1914-15.

The following are the lines of work in progress :—

Major investigations.

1. The economics of cultivation by steam and motor engines.

2. The puddling of rice land by the double engine system of steam cultivation.

3. The combination of irrigation and drainage in the growing of rice.

4. A study of inheritance of the more important characters of dairy cattle by crossing.

5. The building up of milk pedigree in cattle by selection.

Minor investigations.

6. The inheritance of wool characters in sheep.

7. Experimental tillage in the growing of maize and sugarcane.

8. Improvement of pastures.

REPORT OF THE IMPERIAL AGRICULTURAL CHEMIST.

(J. WALTER LEATHER, V.D., PH.D., F.I.C.)

I.—ADMINISTRATION AND TOURS.

Charge.—The section was in the charge of myself during the whole year.

Establishment.—Mr. H. E. Annett, Supernumerary Agricultural Chemist, returned from study leave on 28th November 1913 and was appointed Agricultural Chemist, Bengal, on 1st January 1914.

Mr. Jatindranath Sen, First Assistant in this section, was appointed Supernumerary Agricultural Chemist (probationary) on February 9th, 1914.

Mr. Jatindra Nath Mukerjee, Second Assistant, was appointed First Assistant on 9th February 1914.

Mr. A. V. Iyer, a former assistant of this section and latterly Assistant Agricultural Chemist, Sabour, was appointed Second Assistant on 2nd July 1914.

Babu Har Dyal Singh, a junior assistant, was transferred to the Bacteriological Section on 25th May 1914.

Babu Shasanka Bhushan Roy, L.Ag. (Sabour), was appointed (probationary) to the vacant assistantship on 23rd June 1914.

Tours.—The following tours were made by me :—

1. August 1913. To Meerut and Delhi to discuss the value of certain fodder grasses and grass lands with the Assistant Director of Grass Farms. To Roorkee where I discussed the construction of certain instruments with the Superintendent, Canal Foundry and Workshops. To Cawnpore where I examined the condition of certain lands which had been broken up with explosives.

2. October 1913. To Peshawar to inspect the sugar-beet crops and to arrange for the prospective tests of sugarcane and sugar-beet at Tarnab.
3. December 1913. To Coimbatore to attend the meeting of the Board of Agriculture.
4. January 1914. To Peshawar to inspect the work of the assistant who had been posted there to test sugarcane and beet.
5. March 1914. To Bareilly to discuss the practicability of the small factory for sugarcane and sugar-beet with the Sugar Engineer.
6. April and May 1914. To Peshawar, (*i*) to inspect the work on sugar-beet and to discuss the data with the Agricultural Officer; (*ii*) to take samples of soil from the Upper and Lower Swat River Canals. To Lyallpur to act as a member of the Board of Examiners at Agricultural College.
7. June 1914. To Peshawar on account of sugar-beet analyses.

II.—Education.

Four students have been under instruction during the year. One Government and one private student completed their full courses; one Government student has completed the course (one year) specially prescribed for him. One private student who was studying for the D.Sc. degree, Allahabad, worked here for eight months on a piece of research.

III.—Meteorology.

In addition to the usual data which are recorded daily on behalf of the Meteorological Department, records of (*a*) soil temperature, (*b*) drainage, and (*c*) pressure by means of a barograph have been maintained.

IV.—Soil Problems.

Drainage.—The records of drainage are maintained and it is probable that another collection of data will be published early next year.

Lime and Magnesia.—The relationship between the amount of gaseous carbonic acid in soils and the amounts of lime and magnesia in solution has been the subject of an investigation which has been conducted by Mr. Sen and myself. The first section of the work was published in 1909 and dealt with the relation between calcium carbonate and gaseous carbonic acid. The second section dealt with the corresponding relationship of magnesium carbonate and carbonic acid. Following this we ascertained the solubility of the two carbonates when present together and also of dolomite under like conditions. It then transpired that if magnesium carbonate is present in anything more than quite small quantities, calcium carbonate becomes practically insoluble. Dolomite was found to dissolve as a double salt in carbonic acid, but the maximum concentration which we could obtain was smaller than was anticipated from a consideration of the other work. The presence of either calcium carbonate or magnesium carbonate was found to protect dolomite from the action of carbonic acid. Magnesium carbonate protects it practically entirely, because it rapidly forms a solution of bicarbonate so concentrated that no appreciable amount of calcium carbonate can dissolve in it and hence the dolomite cannot dissolve. Calcium carbonate does not protect it quite so perfectly, but this salt rapidly forms, in contact with carbonic acid and water, a solution of bicarbonate so strong that little or no more calcium carbonate can dissolve in it and hence the dolomite can only dissolve to a limited degree.

This work has shown that no fertile soil can contain material proportions of magnesium carbonate, for if it did, the lime would become practically insoluble and the plant would die of lime starvation. This is probably the reason why in so many of the experiments which have been made in Europe and America on Loew's lime-magnesia ratio in

soils, the application of magnesite or magnesium carbonate has proved so harmful. The details of this investigation have been published as *Memoirs of the Department of Agriculture in India, Chemical Series*, Vol. III, No. 8.

Swat River Canals land.—A number of samples of soil from the land which has been irrigated by the Lower Swat River Canal and from the land which will come under the Upper Swat River Canal were taken during April and May by the Superintending Engineer and myself from places, the exact position of which has been registered with reference to certain bench-marks on the canals. This latter was done in order that samples may, if desired, be taken from the same places on a future occasion. The original object of taking the samples was to supply information respecting the soil to an engineer in England who has asked for information respecting the chemical composition of these soils. In addition to this, however, Mr. A. J. Wadley, the Superintending Engineer, was himself interested in the subject, and the series of samples was for this reason somewhat increased.

The lands which are commanded by these two canals are very similar, in that they consist of the alluvium which lies at the foot of the Himalayas in this part of India, and although close to the low hills, and indeed some of the isolated outcrops occur in the alluvium, it consists almost entirely of fine alluvium without stones. The land which will come under the Upper Swat River Canal lies close to the hills; that which has been irrigated by the Lower Swat River Canal lies further south. Only certain items in the composition of the soils were determined, those indeed which are most likely to indicate their agricultural value or defects. In respect of *calcium carbonate*, this constituent varies within wide limits, being as high as 10 per cent. or more in four samples and as low as ·04 per cent. in three. Usually there is a sufficiency for agricultural purposes, but when the proportion falls as low as ·04 per cent. it will probably pay to add lime. Of *phosphate* in a readily assimilable condition there is in some cases a deficiency.

and it is very probable that if artificial manures are ever used in India generally, it will pay to use superphosphate on some of these lands. Of *potash* there is an abundance, whilst of *organic nitrogenous matter* there is the same deficiency that is so common to Indian soils. Respecting their physical condition they are generally good.

A question was incidentally raised as to whether the lands under the Lower Swat River Canal had deteriorated at all. So far as one can tell from these samples, and they were taken from widely separated places, there was nothing to indicate that any depreciation has occurred, and in fact generally these were richer and better than those from the other area.

The Percolation Test for soils.—Some years ago I devised a method for testing the permeability of soils to water. Its immediate object was then the differentiation of certain *usar* soils of the United Provinces.

During the past year a long series of tests with it have been applied to good agricultural soils in order to ascertain its more general applicability. The test appears to make a sharp differentiation between soils which are physically good or bad respectively. The information which has been gathered on the subject will be submitted for publication shortly.

V.—Saltpetre.

The experiments on improvements in the saltpetre refining process advanced a stage this year. A filter press was obtained from Europe which has shown itself able to deal with the mud very expeditiously. The pumps supplied with the press were, however, defective and another mode of applying the liquid to the press will now be tried

In the meantime the solubility relations of the chief salts which are present have been worked out by Babu Jatindra Nath Mukerjee and myself and published as *Memoirs of the Department of Agriculture in India, Chemical Series*, Vol. III, No. 7.

VI.—Sugar.

The work of this section on sugar has been confined to a series of investigations at Tarnab Farm, North-West Frontier Province.

Reference was made in my last Annual Report to the tests of the sugar-beets which Mr. Robertson Brown had grown, and to the fact that the quality of the roots had proved to be very good.

It has been evident throughout in respect to this crop, that the subject must be considered from the manufacturing standpoint, because of the fact that marketable sugar could only be produced from the beet root in a factory. This alone necessitates a regular supply of roots over at least several months because otherwise a factory could not hope to pay. It followed therefore that the next desirable step in the work was to ascertain over how many months this crop could be satisfactorily produced. Mr. Brown agreed in this view and decided to sow plots of sugar-beet at intervals over several months.

A consequence of this decision was that arrangements had to be made for the testing of the crops over a considerable period, and it was therefore decided to take this opportunity of also testing the local sugarcane as also other varieties of cane at the Tarnab Farm in as thorough a manner as possible.

A third investigation now presented itself. It is customary in that locality to bury sugarcane in December in order to preserve it for planting out in the following April. The crop is all harvested in December and January, and cane could not be suitably left standing in the field until the succeeding time of planting. The method of preserving the cane in " clamps " is therefore adopted, and for the end in view the method is very perfect. The question then occurred, does cane, which is preserved in this manner, deteriorate from the manufacturer's standpoint? We decided therefore to include some tests on this question The investigations had thus to do both with cane and beet.

Sugarcane.—There is a considerable area of sugarcane in the Peshawar Valley, which consists principally of a "thick" variety, yielding heavy crops. A number of samples, each consisting of about 200 canes, were tested in December and January and the following examples illustrate the general quality :—

Date.	Village.	Juice per cent.	In Juice.			
			Brix.	Sucrose per cent.	Glucose per cent.	Coefficient of purity.
28-11-13 .	Tarnab .	76·71	14·87	12·03	1·92	80·9
2-12-13 .	Zakki .	74·72	15·40	12·24	2·27	79·5
15-1-14 .	Tarnab .	76·92	15·60	13·10	1·67	84·0
19-1-14 .	Tarnab .	77·65	15·90	13·65	1·49	86·1
3-2-14 .	Tarnab .	...	16·10	13·89	1·39	86·0

The proportion of juice was obtained by crushing the cane in a Nahan bullock power mill. It will be seen from the above examples that it is a cane containing a high proportion of juice. United Provinces canes for example yield only some 60—65 per cent. juice to such a mill. The percentage of sugar in the juice is rather low. As the season advances the quality improves. From the manufacturing standpoint the comparatively low percentage of sucrose is made up for in a great measure by the high proportion of juice and low fibre content, which reduces the necessary maceration. The crushing season is limited to the months December and January.

Other canes tested were imported varieties grown at the Tarnab or Haripur Farms, *e.g.*, Striped Mauritius, Purple Mauritius, Saharanpuri, Partabgarhi, etc., most of which proved to be similar in quality to the local *pounda.*

"*Clamped*" *cane.*—The method of "clamping" sugarcane in the Peshawar Valley is similar to that employed in Europe for preserving roots or potatoes. It may be

briefly described. The cane is taken up with the surface roots, leaves and tops intact. The canes are placed on the ground in a neat flat heap, canes lying parallel to one another, and covered with about 6″ of earth; they then remain undisturbed until the planting season in April. Two experiments were made in order to ascertain whether the cane depreciates when kept in " clamps "—the one was made early in December when four lots of cane, each of about 4·5 maunds, were put in " clamps," the cane being very carefully sampled* and tested at the time; the other was made on January 15th, when two lots of about 9 maunds each were clamped. The cane which was " clamped " in December remained for 21 days in the " clamp;" that of January was left until May and was tested at intervals of about one month. The data obtained are collected in the following statement:—

Composition of sugarcane before and after clamping.

Variety.	Date of putting in clamp.	Date when tested.	Juice per cent.	Juice.			
				Brix.	Sucrose per cent.	Glucose per cent.	Coefficient of purity.
Striped Mauritius.	24-11-13	...	65·78	14·27	10·86	2·22	76·12
		15-12-13	67·27	14·10	10·60	1·92	75·19
Striped Mauritius.	26-11-13	...	71·96	15·09	12·11	1·61	80·27
		17-12-13	69·14	14·66	11·33	1·82	77·29
Local pounda .	28-11-13	...	76·71	14·87	12·03	1·92	80·93
		19-12-13	71·73	15·09	12·09	1·92	80·10
Local pounda .	2-12-13	...	74·72	15·40	12·24	2·27	79·50
		21-12-13	67·78	15·13	12·11	2·08	80·05

* For a discussion of errors in sampling sugarcane see *Mem., Dept. Agri., India, Chemical Series*, Vol. III, No. 4.

Composition of sugarcane before and after clamping—contd.

Variety.	Date of putting in clamp.	Date when tested.	Juice per cent.	Juice.			
				Brix.	Sucrose per cent.	Glucose per cent.	Coefficient of purity.
Local pounda .	15-1-14	...	76·92	15·60	13·10	1·67	83·99
A		16-2-14	76·31	15·20	12·22	1·85	80·37
		24-3-14	72·50	15·40	12·82	2·04	83·22
		24-4-14	70·73	14·90	12·66	1·52	84·91
Local pounda .	15-1-14	...	76·72	15·90	13·65	1·54	85·84
B		16-2-14	73·25	16·00	12·97	1·75	81·08
		24-3-14	72·40	15·10	12·11	2·00	80·21
		24-4-14	71·59	14·85	12·19	1·67	82·09

An examination of these figures shows that the following deductions may be drawn :—(*i*) There was probably some reduction in the proportion of juice in the cane, due to loss of moisture during the period it was in clamp. Whether this was so during December is doubtful, but it certainly occurred during the three months from January to April. This is almost to be expected owing to a certain amount of drying; at the same time it is to be remembered that there is the error due to sampling, especially when, as in February, March and April, canes had to be drawn out of the heaps. Another error rests with the mill, which cannot be always tightened up equally at different times. Regarding the sucrose, glucose and purity, these did not change during December, the small variations which were found by analysis must be attributed to experimental error chiefly in sampling. The results of the December experiments are indeed remarkably satisfactory. During the much longer period January to April, the individual tests of the experiment marked "A" exhibit some variations no doubt due chiefly to sampling, but it is evident that except that the cane dried somewhat, this lot of cane suffered no

appreciable change. The lot of cane marked " B " probably suffered some small depreciation, but it was subject to slightly different circumstances. It has been mentioned that the local practice is to take up the cane with its surface roots intact. If, however, this mode of preserving cane for a factory were adopted, it was thought that this factor would add somewhat to the cost, costing rather more to lift from the ground and rather more to carry. Hence the lot of cane marked " B " was clamped without roots, but with leaves intact. This cane, as also all the other, remained practically perfectly sound, only the cut ends of the cane showing signs of rotting. This factor probably accounts for the somewhat greater depreciation of the juice, though it may be also partly due to error of sampling.

In any case these experiments show that sugarcane may be preserved in clamps over considerable periods practically intact.

Gur.—A number of samples of the locally made *gur* were analysed. These varied (with one exception) from 70—74 per cent. sucrose, and from 12—15 per cent. glucose.

Sugar-beet.—Two varieties of sugar-beet were sown, namely, Vilmorin and Klein Wanzleben. One plot of the latter was sown on September 20th, and plots of the former were sown on October 10th and 20th, November 10th and 20th and February 20th. Germination and subsequent growth were very good and uniform. Tests of these plots were made frequently, commencing naturally with the earliest sown. The samples consisted at first, in each case, of about 20 roots taken from uniformly distributed points over the plot, which enabled one to form an opinion on the progress of sugar formation, and so soon as the roots appeared to be well grown, the number of the roots was increased to about 100 per sample, taken similarly from uniformly distributed points. Not only do such samples yield accurate information as to the quality of the crop, but, together with a knowledge of the number of roots per plot, indirectly of its weight.

For example the following instances may be quoted to show how well duplicate samples agree :—

Year.	Number of roots.	Average weight per root, grms.	Estimated weight per acre, tons.	Sucrose in root per cent.
1913	100	756	.....	14·68
	100	711	.....	14·73
1914	97	612	14·9	11·9
	96	647	15·8	12·3

The following conclusions were drawn regarding the beet root crop :—

(*i*) The average weight per root reached approximately 1 lb. at the end of six months from date of sowing if sown between September 20th and November 20th. Those sown on February 20th grew faster, and were fit to crush in June.

(*ii*) The percentage of sugar was found to be between 12 and 13 in Klein Wanzleben and between 10 and 11 in the Vilmorin when the roots were still quite small.

(*iii*) While the cold weather lasted the sucrose percentage remained rather low, but so soon as the hotter weather set in at the end of April there was a marked increase at least in all those sown on or before November 10th; thus we have :—

Sown.	Date of sample.	Sucrose per cent.
September 20th	April 21st	13·1
	May 7th	15·6
October 10th	April 22nd	11·2
	May 14th	15·3
October 20th	April 23rd	10·5
	May 15th	14·7

(*iv*) The percentage of glucose was about ·1 per cent. in each case.

(*v*) The coefficient of purity was found throughout to vary from 80—90.

(*vi*) The weight of roots was estimated to be about 20 tons per acre at the time of optimum quality.

(*vii*) The roots sown February 20th were not tested later than May 31st when the sucrose had risen to 12·2 per cent., but they were perfectly sound and growing well at the end of June.

It is thus fairly evident that sugar-beets of good manufacturing quality can be grown so as to be ready by the middle of March, and by sowing on successive dates, the supply could be maintained until the end of June.

This investigation of the sugar capabilities of the Peshawar Valley has thus shown that—

(*i*) sugarcane can be had in the field during December and January,

(*ii*) that sugarcane may be preserved in a sound condition in clamps over the months February and March, and

(*iii*) that a sugar-beet crop could be grown so as to supply a factory from the middle of March until the end of June. The factory would naturally have to be fitted to deal with both crops, but there should be no difficulty in arranging for this and the potential length of campaign, six or seven months, is unusually long.

Production of sugar-beet seeds.—A number of roots were transplanted for seed this year and some of these were tested at the time of transplanting, so that if seed is obtained, their progeny can be again tested and the process of selection of acclimatised plants commenced.

VII.—Milk.

Milk of Montgomery cattle.—Between December 1911 and June 1912 a series of tests of the quantity and quality of the milk of selected cows of the Montgomery herd at

Pusa was made in collaboration with my colleague Mr. A. C. Dobbs, then Imperial Agriculturist. The precautions which we employed in order to avoid experimental error as far as possible are dealt with in a succeeding paragraph.

Although the analytical part of the work was naturally completed day by day at the time, it was necessary, in order that the data obtained might have their full value, to examine them carefully and ascertain the probable errors mathematically. This portion of the work was done during the hill recess 1913, and explains why the subject was only briefly referred to in my last Annual Report.

Altogether three series of tests were made; with three cows in December and January; with twelve cows in April and May; and with ten cows in September to November. Most of these cows had calved recently and were in " full milk " or " fairly full milk."

Regarding the *yield* of milk, one half was obtained by hand milking (see succeeding paragraph) and from these data the total *production* of each cow was ascertained. This varied considerably, being as small as 8 lbs. in one case and as high as 18 lbs. and 21 lbs. respectively in two others. The majority produced from 10 to 14 lbs. per 24 hours. The *morning* and *evening* yields were found to be approximately equal in all cases; the periods between milking were 12 hours each. In respect of *fat* the percentage varied generally from 4 to 6, but was as low as 3·5 in one or two instances. The percentage of *solids-not-fat* varied from 8·2 to 9·0.

The *morning* and *evening* milk was not equally rich, the morning milk being systematically richer by about 1·0 per cent.; in some cases the difference was as small as ·3 per cent., in others as high as 1·5 per cent.; the mean difference for the 25 cows was ·91 per cent.

Tests of the yield and composition from *different parts of the udder* showed that :—

(*i*) Usually the *yield* is approximately equal from the right and left side respectively, though there

were five cows which produced more milk from the one than from the other half udder.

(*ii*) In respect of *fat percentage*, with one exception, the milk was of equal richness from either half udder. The *quality* of the milk from the several *quarters* of the udder was tested in December and January for three cows, and here characteristic differences were met with, for in one case the milk was systematically richer from the fore, than from the hind-quarter, in another case it was systematically richer from the hind, than from the fore-quarter, whilst the third cow showed no such characteristic differences. Whilst the number of instances is so small that one cannot say that such instances are not exceptional, the tests were conducted over so long a period, upwards of two months, that the data are not to be ascribed to accidental error; they are real differences for the two cows, however exceptional such cows may be.

Errors involved in making milk tests.—When we decided to make a series of milk tests of the Montgomery cattle, it was apparent that an attempt should be made either to avoid several errors which are liable to occur and which very frequently minimise the value of such tests, or to estimate their magnitude. These may be briefly summarised.

(*i*) The number of cows should not be very small. Only three were included in the first period, but twelve and ten cows respectively were employed in two subsequent periods.

(*ii*) If the periods elapsing between milkings are unequal, it is known that this alone affects both the quantity and quality of the milk. As there was no difficulty at Pusa in making these periods equal, all the cows were milked at 12 hours' intervals, the variation in length of this period being not more than 5 minutes, which is a negligible quantity.

(*iii*) In India it is usually difficult to persuade a cow to yield milk to the hand without the calf sucking at the same time. At Pusa this was found to be regularly so. But obviously if the calf takes an unknown quantity of the milk, the total yield cannot be correctly ascertained; and without the adoption of special precautions this factor affects the percentage of fat also. The practice at Pusa with this herd is to allow the calf to take all the milk of one side of the udder whilst the other half is hand drawn, the idea being to ensure that the calves have a liberal allowance. It remained therefore to ascertain whether this practice is accompanied by any systematic errors, *e.g.*, is the one half udder as thoroughly stripped by hand as the other half is by the calf? The system which we adopted for these tests was to allow the calf to take the milk from one half udder, say the right, whilst the left half was hand milked, for two milkings; then for the following two milkings the calf was given the left half, whilst the right half udder was hand milked; and this sequence was followed day by day. During the first half of the period, *i.e.*, approximately for one month, the change from right to left side was made at the morning milking, whilst during the second half period, it was made at the evening milking. By the adoption of this system of milking it was evident that if the calf obtained more milk than the man (*i.e.*, if the hand milking were the less perfect) or if more milk were secreted during the night or day time, *systematic* differences of yield would be perceptible in the records which could be traced to one of these two causes. The data showed no such systematic differences and it became evident that the calf and man were equally efficient in stripping the udder. The source of error due to not being able to milk these cows entirely by hand, was thus avoided.

An examination of the data, both of yield and of percentage of fat, showed that the probable error of *individual* tests was unusually small. The probable error of yield for individual milkings was only $\pm$ ·27, and for percentage of fat it was only $\pm$ ·29, which are small when compared with

similar records which have been obtained elsewhere. The principal deductions depended on the arithmetical means of all the tests of any one period, and the probable error then fell to rather less than ± ·1 both in the case of yield and percentage of fat. We were thus enabled to decide with great accuracy what differences were due to error of experiment and what were real differences in yield or quality.

Error due to milking in the ordinary way.—During a part (28 days) of the third period, September to November, the ten cows were hand milked as for profit, that is, the calf was allowed as little as possible, the object being to ascertain the magnitude of the errors which such a method would incur. The yields by hand were about 50 per cent. greater during this time, which was to be expected. It is also obvious that under such conditions the real quantity of milk secreted could not be ascertained. But in addition to this, the probable error of an individual milking rose from ± ·26 to ± ·74, that is, it became three times as great.

Detection of added water in milk.—During recent years the reliability of the freezing point of milk as a criterion of its freedom from added water has been recommended, chiefly by Brownlie Henderson in Queensland. It has been found by him and others that the freezing point of pure milk is so constant that a comparatively small addition of water, *e.g.*, 2 per cent., can be detected. At present the method is purely empirical and would only become dependable if a large number of tests showed what the variation of freezing point of pure milk is. To this end the freezing point of the milk of a number of individual cows and buffaloes at Pusa, at the Lyallpur Agricultural College and at the Military Dairy Farm, Peshawar, was determined, and it seems certain that even among individuals the variation in freezing point is only small. At Pusa it varied from − ·543° to − ·577°C., at Lyallpur from − ·527° to − ·562°C., and at Peshawar from − ·529° to − ·564°C. The variations between individuals are naturally greater than between samples of the mixed milks of a herd; thus

the freezing point of cow's milk at Pusa was −·555°C., at Lyallpur −·547°, at Peshawar −·537°, and buffalo's milk at Peshawar −·552°. The standard freezing point assumed by Winter is −·550°C., and a freezing point −·537°C. is equivalent to 2·36 per cent. of added water. Thus for mixed milks 5 per cent. of added water could be detected with certainty, whereas if dependence is placed on the percentage of solids-not-fat, there are cases where 10 per cent. could not be sworn to. Using Pusa cow's milk, to which known amounts of water were added, the freezing point indicated the following percentages of water :—

Indicated.	Actual.
5·6	5·0
10·9	10·0
19·0	20·0
21·3	25·0

VIII.—Programme of work for 1914-15.

Major subjects:—

1. Examination of the sugarcane and sugar-beet crops at Peshawar and the storage of these crops in " clamps."

2. Experiments on possible improvements in the refining of saltpetre will be continued.

3. Records of the amount and nature of drainage water from fallow land and from land bearing crops are maintained.

4. An investigation of certain of the constituents of *Lathyrus sat.* is being conducted by the Supernumerary Agricultural Chemist.

5. The ratio of Argon to Oxygen and Argon to Nitrogen in soil gases under certain specified agricultural conditions is being determined.

Minor subjects:—

6. An attempt is being made to ascertain the nature of the hydration of clay in soils.

IX.—Publications.

The following have been issued :—

1. The Yield and Composition of the Milk of the Montgomery herd at Pusa and Errors in Milk Tests. J. W. Leather and A. C. Dobbs. *Mem. Dept. of Agri. in India,* Chem. Ser., Vol. III, No. 6.
2. The System Potassium Nitrate, Sodium Chloride, Water. J. W. Leather and Jatindra Nath Mukerjee. *Mem. Dept. of Agri. in India,* Chem. Ser., Vol. III, No. 7.
3. The systems (A) Water, Magnesium Carbonate and Carbonic Acid, (B) Water, Calcium Carbonate, Magnesium Carbonate and Carbonic Acid. J. W. Leather and Jatindra Nath Sen. *Mem. Dept. of Agri. in India,* Chem. Ser., Vol. III, No. 8.

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REPORT OF THE IMPERIAL ECONOMIC BOTANIST.

(A. HOWARD, C.I.E., M.A., A.R.C.S., F.L.S.)

I.—STAFF.

Charge.—I held charge of the section at Pusa during the year under review from October 18th, 1913, till June 30th, 1914. During the remainder of the period, I was on combined leave when the Second Assistant, Maulvi Abdur Rahman Khan, was in charge of current duties at Pusa. This assistant did good work during my absence and was rewarded by the grant of a charge allowance.

Staff.—The work of the staff continues to be satisfactory. In addition to the assistant mentioned above, the only case for individual mention is that of Lal Singh, who has been promoted to the post of Second Fieldman at Pusa. Fieldman Ram Prasad died during the year when the section lost the services of a loyal and hard-working man.

II.—WHEAT INVESTIGATIONS.

Distribution of Pusa Wheats in India.

In previous annual reports, a full account has been given of the preliminary work connected with the production and also with the trial of Pusa wheats in the various wheat-growing tracts of India. At the same time, reference has been made to the investigations on the influence of the environment on the milling and baking qualities of these wheats, which have been carried out in collaboration with Mr. Leake and with the invaluable help of Mr. A. E. Humphries. It is not proposed to refer now in detail to these preliminary matters which were fully described in the annual reports for 1911-12 and 1912-13.

The outstanding feature of the work of the last year has been the demonstration of the fact that one of the new wheats, No. 12, is the best for general cultivation both in the Gangetic plain and also on the black soils of Peninsular India. This wheat has also given satisfactory returns, both as regards yield and quality, in the *barani* tracts of the Punjab where it is now being grown by the cultivators. The behaviour of this variety is of the greatest importance in the work of improving the wheats of India. Judged by the returns obtained by the people themselves, not only in almost every District from Gurdaspur in the Punjab through the United Provinces to Bhagalpur in Bihar, but also on the black soils in Bundelkhand and in the Central Provinces, this wheat has invariably given the highest yield. At the same time, it has been demonstrated that its milling and baking qualities have been maintained unimpaired, both under *barani* conditions and also under canal and well irrigation. In addition to the satisfactory yield, the numerous trials of Pusa 12 by the cultivators in the United Provinces, during the last wheat season, have brought out the fact that it is able to maintain itself with far less water than late sorts like Muzaffarnagar, which need at least one more watering. Pusa 12 is a red chaffed wheat with good straw and its characteristic appearance in the field is of considerable advantage in the work of replacing the country wheats, which for the most part are shorter in the straw and have white chaff. The grain is white in colour and larger and more attractive than Muzaffarnagar. A single improved grade of white wheat can now be grown over a very large portion of the wheat-growing area of India. This will be an enormous advantage to the export trade and at the same time will be of great use from the point of view of the food of the people. For local consumption, Pusa 12 is worth at least two annas a maund more than ordinary Indian wheat.

Pusa 12, when placed on the Calcutta market for the first time this year, found a ready market at the mills and fetched four annas a maund above Bihar wheats on its

appearance alone. This fact is promising from the point of view of the first shipment of this wheat to Great Britain.

The distribution of Pusa 12 to cultivators is now being actively taken up by the Agricultural Departments of the United Provinces, the Punjab, Bihar and Central Provinces and all the available seed has been distributed. The supply, however, was far below the demand and, in particular, the indents from the United Provinces could only in part be met. Steps have been taken to remedy this and it is expected that the seed farms in Bihar and some of the indigo estates will be able to provide about 10,000 maunds of Pusa 12 in April 1915 to supplement the general seed supply of the Agricultural Department. On the indigo estates in Bihar, Pusa wheats are now almost exclusively grown and wheats like Muzaffarnagar have been given up.

A beginning has been made during the present year in the work of growing sufficient Pusa 12 at a few centres in the Central Circle of the United Provinces so that the surplus can be sent as a special shipment to England for the purpose of introducing this wheat on the Home markets. The co-operation of Mr. B. C. Burt, the Deputy Director of Agriculture, has been secured in this matter and the necessary financial assistance has been given by His Honour the Lieutenant-Governor of the United Provinces and by the Agricultural Adviser to the Government of India. By taking advantage of the development of the Co-operative movement in this Circle, it is hoped to replace systematically, from certain centres, the country wheats by Pusa 12 over large areas. The experiment is an interesting one, not only from the point of view of the trade in an improved product, but also as a means of discovering how far the Co-operative movement can be used in the distribution of an improved variety in a systematic way.

Another aspect of the success of Pusa 12 over so large a portion of the wheat-growing area of India remains to be considered. It is sometimes stated that the agricultural conditions vary so much in India from province to province and also in different parts of the same province, that

the work of improving any widely cultivated crop can only be done locally and at a number of stations. In reality this idea is not supported by the facts. It is true of course that the conditions under which wheat is grown in India vary widely, and that a knowledge of these conditions is essential in the work of improving the crop. It is also true that a single area of fifty acres in the Gangetic alluvium, if skilfully selected, exhibits an exceedingly wide range of soil conditions, which, from the point of view of the requirements of the wheat crop, vary almost as much as any two of the wheat-growing provinces of India. By taking advantage of this circumstance, it is possible to make a single wheat-breeding station serve for almost the whole of India.

Wheat Breeding.

The fourth generation of the crosses between Indian and English wheats, referred to in the previous report, have been worked through during the year. A large range of individuals has been selected for further growth, all of which are characterised by strong straw, rust resistance and attractive looking grain. The range in time of ripening of these plants is very great. Some are earlier than Pusa 4 while among those with enormous tillering power are numerous individuals which will probably ripen too late for any of the wheat tracts of India except possibly the Quetta valley. This group of wheats is by far the most promising material obtained at Pusa. Some types will probably be fixed in 1915, after which they will be tried in the various wheat-growing tracts.

III.—Other Investigations.

Tobacco.—Progress continues to be made in the tobacco investigations at Pusa.

Further results have been obtained with the cigarette tobacco known as Type 28. A good many of the indigo estates in Bihar are now growing this tobacco for the Indian Leaf Tobacco Development Company at Dalsing Serai and.

in April last, an increased quantity of self-fertilized seed was distributed. The yield of this tobacco under estate conditions is very satisfactory and it is also being taken up by the cultivators for the local trade. On a few estates, Type 28 is being cured on racks, the price obtained for the first quality leaf being Rs. 25 per maund. Arrangements have been made to grow at Pusa the seed of this tobacco required by the planters and others so that this variety can be maintained true to type and natural crossing prevented.

The importance of improved methods of growing the seedlings of this crop was referred to in the last report. By partially sterilizing the seed beds, the seedlings grow faster and stronger and are ready for transplanting about a week or so earlier than when grown in the ordinary way. It is a great advantage in Bihar to be able to rely on an abundant supply of strong seedlings at the proper time so that even fields can be established on the *hathia* rains. Work is in progress at Pusa with the object of devising the most economic method of adapting the results obtained to estate conditions.

Interesting results were obtained during the year on green manuring for tobacco with *sanai* (*Crotalaria juncea*, L.). These results supplement those already published in the *Agricultural Journal of India* (Vol. VII, 1912). It was found then that if the interval of time between ploughing in the green crop and transplanting the tobacco exceeded two months, the effect of the green crop diminished and finally disappeared altogether. During the past year, the effect of diminishing the time between ploughing in the *sanai* and planting the tobacco was tried. It was found that any period less than two months was too short for the decay of the green manure and when the period was less than one month the crop obtained was very poor. Across the plots in which the *sanai* had less than two months to decay, a broad strip was subsoiled some time after the green crop was put under. The result was a great improvement in the vigour of the tobacco crop and the subsoiled strip stood out markedly from the rest. It is prob-

able that these latter results can be explained by the work of Kidd (*Proc. Roy. Soc.*, B, Vol. 87, 1914) who has shown that the decay of green manure produces so much carbon dioxide in the soil as to inhibit the germination of seeds. Until a certain stage is reached in the decay of a crop like *sanai*, it is quite possible that want of oxygen and excess of carbon dioxide would be limiting factors to a rapidly growing crop like tobacco. That a poor germination is obtained if seeds are sown soon after a green crop of *sanai* is ploughed in, was observed twice during the past year at Pusa, once in the case of Java indigo and once in the case of tobacco sown in a nursery which had been recently green manured with *sanai*. The absence of any marked crop increase on the heavy lands in Bihar, following a dressing of *seeth*, and also the poor crops obtained on such lands after *sanai* ploughed in (especially in wet years or when the soil is waterlogged by flooding) are probably also connected with oxygen supply. Kidd's researches are likely to prove of considerable interest to India.

A paper is in preparation, by the Personal Assistant, on the inheritance of characters in *Nicotiana rustica*, L., the observations on which were brought to a conclusion during the year.

Gram.—The selection work on this crop was continued and three of the most promising types, including the high yielding white gram which was valued so highly at Bombay in 1912, have been distributed for trial on estates in Bihar and also in other tracts of India. A certain amount of natural crossing takes place in this crop, the extent of which under Bihar conditions is now being investigated.

Fibres.—The work on the inheritance of characters in *Hibiscus Sabdariffa* was continued, but it was not found possible to complete this investigation during the year. The work is being continued.

The behaviour of some of the cultures of *sanai* (*Crotalaria juncea*) at Pusa indicated that extensive natural crossing takes place in this crop when two or more varieties are grown next to next. The pollination mechanism in the

flower has been worked out and the functions of the long and short stamens elucidated. Very little selfing under nets takes place in this crop, the flowers only setting seed normally after being visited by bees. These facts render variety trials in this crop exceedingly difficult.

Methods of pollination.—It is hoped during the next few months to bring out a second memoir dealing with natural cross fertilization and to include in it the observations of this subject made at Pusa since the first memoir was published in 1910.

Drainage.—The great importance of a system of surface drainage in Bihar, which allows each field to deal with its own rainfall only and also prevents the loss of fine soil by surface wash, has been observed for some years at Pusa. The subject has been brought to the notice of the planting community in Bihar in a paper read at the meeting of the Bihar Planters' Association in January last. The Pusa method has been taken up with success on several estates and a great deal of attention is now being devoted to the subject. On the Dholi Estate, the lands are being divided up into drained areas about five acres in extent so as to admit of the use of reapers and other labour saving devices in the cultivation of wheat for seed purposes. Mr. Danby, in a letter dated January 3rd, 1914, gives his opinion on this system of drainage as follows :—

" During the past year I have applied the system of surface drainage to some 40 bighas and I intend to extend it to the whole of my factory *zerats* here and at the outworks. The lands which I drained in this way this year were formerly, in a wet year, more or less waterlogged the whole of the rains owing to the water from the higher lands draining into them. This year I was able to cultivate and keep them clean all through the rains and even after the late rains which we had this year I was able to sow wheat in them before the end of October."

A note on the subject of drainage and soil denudation by rain wash was submitted to the Board of Agriculture at

Coimbatore. This has since been published in the *Quarterly Journal of the Indian Tea Association.*

Indigo.—The present position of the indigo investigations has been dealt with, in detail, in a report to the Bihar Planters' Association published in January last.

The area under Java indigo in Bihar has fallen since 1909-10 from 70,000 to about 15,000 bighas in 1913. During this period, the area under Sumatrana indigo has remained constant at about 45,000 bighas. The decline in the area under Java indigo has been a serious blow to the planting community in Bihar. As is well known, this species is much richer in indican than Sumatrana which latter was exclusively grown in Bihar till the introduction of Java indigo in 1898. The rapid increase in the area under the Java plant gave rise to the hope that the decline of the natural indigo industry would at least be arrested. Difficulties, however, arose after the cycle of dry seasons came to an end in 1908. The crop showed signs of falling off in vigour, the yield of leaf became less and difficulties in growing the crop for seed were of frequent occurrence. The poor seed sown gave rise to still more weakly crops with the result that the area declined eighty per cent. in four years. The cause of the trouble is regarded locally as a disease to which the name of ' wilt ' has been given. The nature of the disease has been investigated both by the Sirsiah Experiment Station and also by the Mycological, Entomological and Bacteriological Sections of the Pusa Research Institute.' In all cases the results obtained were negative. The matter was also referred to the Botanical Section at Pusa. It was found that the wilting of Java indigo, which takes place after the first cut in July, was due to the loss of the active root system of the plant, resulting from a long continued wet condition of the soil. Similar wilting is common in Bihar in crops like *patwa* (*Hibiscus cannabinus*) and *sanai* (*Crotalaria juncea*) when sown at the beginning of the monsoon for seed purposes. All these deep-rooted crops are sensitive to a constantly wet

soil and lose their active root system if this condition persists for too long a period.

In searching for some practical remedy for this trouble, two lines of attack suggested themselves. In the first place, improvements in surface drainage and aeration of the soil might be expected to prolong the life of the plant. Secondly, sowing the crop specially for seed towards the end of the monsoon, so that the developing root system would follow the fall of the subsoil water, was a second possibility in case improved drainage and cultivation failed to avert the trouble in the case of indigo grown in the ordinary way. Both these methods were tried simultaneously.

Among the various methods of surface drainage and interculture, tried during the monsoon on indigo cut for leaf in the ordinary way, no practicable remedy for the trouble was discovered. The waterlogging, which takes place in the fine Bihar alluvium and which leads to the destruction of the young roots of the indigo, cannot be entirely prevented by ordinary surface drainage and cultivation. The plants will not tolerate the constantly moist condition of the soil for the whole of the monsoon period.

In the case of August sown indigo, very different results were obtained. The plants grew rapidly, escaped wilt altogether and gave rise to a fine crop of healthy seed the following March. After reaping the seed, the plants were cut back and then gave a good crop of leaf in the ordinary way the following rains. Similar results were obtained on a large scale on the Dholi estate. The Pusa results showed that, for seed purposes, Java indigo should be sown thickly, in lines about two feet apart, early in August on high, well drained land in good condition. In this way the plants escape the disease. They grow to a large size by the end of October and so carry a heavy crop of seed the following cold weather. Thus one of the main obstacles to the cultivation of Java indigo in Bihar has been removed and the planting community are now in a position to grow their own seed without any great outlay. After gathering the

seed, the indigo can be cut back and good crops of leaf taken the following monsoon.

Attention has also been paid to the method of pollination in Java indigo, from the point of view both of seed growing and of improving the plant in indican production. Pollination by bees is the rule and very few seeds are produced by covered plants. As would be expected from the method of pollination, the progeny of single plants showed that natural crossing is common. These facts indicate that ordinary single plant selection methods in Java indigo are not likely to yield results at all commensurate with the work which this method would involve. Some system of mass selection, in which undesirable forms are eliminated prior to flowering, seems much more likely to lead to improvement. Advantage will have to be taken of those individuals in the mixed crop which grow rapidly and strongly and which by their habit of growth and amount of leaf surface are likely to give the highest yields of green leaf. These will have to be grown separately, away from other indigo, and a process of rogueing carried out before flowering time so that all undesirable types are weeded out and not allowed to cross with the rest. The fact that bees are necessary for the pollination of Java indigo indicates that for seed purposes the plants should be properly spaced and not grown too close together. Copious setting is obtained if the crop is grown in lines about two feet apart. Cultivated in this way, Java indigo branches freely from the ground and there is ample room for the bees.

During the progress of the indigo investigations it became evident that one important method of improvement had been, to a large extent, neglected. In the past, it has been tacitly assumed that the methods of cultivation in vogue in Bihar are more or less perfect and that any line of advance must necessarily begin in the laboratory. The results obtained at Pusa have shown that a considerable degree of improvement is easily possible in the actual grow-

ing of the crop. Further, these improvements are well within the means of an ordinary indigo estate.

After the removal of the cover crop, it is the usual practice in Bihar to weed the young indigo crop by hand. This process is tedious and expensive and the work is not always well done. By the use of lever harrows in the early stages, and by the use of spring tine cultivators later on, a great deal of hand weeding can be avoided and at the same time the young crop is greatly improved by the cultivation. These lever harrows have been tried extensively on the Dholi Estate for two seasons and Mr. Danby reports as follows on the trials (Letter, dated January 3rd, 1914):—

"I meant to have written before about the lever harrows. I had six of these harrows in use last year and I have ordered six more from Messrs. Massey Harris.

"I harrowed practically the whole of my Java crop in February and March last after cutting the cover crop—wheat and *sursoo*. The crop was greatly improved by the harrowing, besides which the wheat stubble and weeds were to a large extent removed. I estimate that the amount saved in weeding alone in one year was more than the cost of the harrows."

Some consideration has been given at Pusa to the discovery of some practicable method of reducing the amount of wilt among Java indigo when grown for leaf. Very promising results were obtained during 1913. As is well known, the universal method of growing Java indigo in Bihar is to sow it either broadcast or by drills in lines close together. The result, in both cases, is a dense crop of unbranched plants among which leaf-fall rapidly takes place due to the crowding of the plants, thus leading to a great loss of indigo. Further, interculture to keep down weeds is impossible after the first cut. When the crop is reaped, the indigo is cut down completely and the plant has to produce new shoots during the monsoon at a time when its roots are in very moist soil. Few plants will survive uninjured such treatment during a heavy monsoon. When an indigo plant is suddenly cut down, the passage of

water and food materials from the roots goes on for a time and the stumps bleed. There are no leaves to carry on the transpiration current and the result is that the normal physiological processes in the plant are greatly upset. It is not surprising therefore that the new growth is formed so slowly and that it is often unhealthy. Many plants, such as peaches and flowering creepers like *Ipomœa*, usually die outright when cut down to the ground during the rains and hardly ever recover. It was decided in 1913 to try the effect of pruning the crop in July at the time of the first cut and to compare the behaviour of plants treated in this way with those cut down completely. The crop was grown in lines, two feet apart, to allow of branching. One half of the plot was cut down in the ordinary way, the rest pruned so that one branch was left at cutting time. The result was that the pruned plants began to shoot earlier than those which had been cut down and moreover escaped wilt to a much greater extent. The total yield from the pruned plot was about thirty per cent. greater than that of the area cut down completely. Work on this subject is being continued with the object of finding the most economic method of growing the crop so that it can be pruned at the first cut instead of being cut down completely.

IV.—The Development of the Fruit Industry of Baluchistan.

In the previous annual report, a complete account was given of the work at Quetta relating to the development of the fruit industry in Baluchistan. A brief reference to the progress made during the past year will suffice to bring this subject up to date.

Fruit and Agricultural Experiment Station.

Considerable progress has been made in the preliminary work relating to the laying out and equipment of the new Experiment Station at Quetta. The land has been laid out in large terraces with a suitable slope for irrigation in two directions. Water can now be brought on to about three-

quarters of the terraces by means of two bricked channels so that the loss of water during irrigation has been reduced to a minimum. The rest of the area is commanded by earth channels only. A pucca road now runs through the area, the farm buildings, which include quarters for the overseers and workmen, have been erected and the work connected with the artesian bores has been completed. One of these bores has been fitted with an oil engine and a centrifugal pump and has been very thoroughly tested by pumping on it for eight hours a day for a month. By this means the flow was increased from one to about three thousand gallons an hour without affecting the normal flow. A certain supply of irrigation water is now assured whatever may be the future of the large *Sirkhi karez* of which two *shabanas* of water belong to the Experiment Station.

The method of ring budding seedlings in May and June has proved a great success under Quetta conditions and during the past year about 2,000 budded trees have been distributed. All the young trees are pruned in the nursery during the first year's growth and properly trained before issue to the public. In order to check waste of stock, all the trees, except those for Government use, were sold at the rate of two to the rupee. At the end of the present year it is expected that from six to eight thousand trees will be ready for distribution.

Experience during the past year has confirmed the opinion given in the last report that by suitable methods of moisture conservation a great saving of irrigation water is possible in Baluchistan. Further saving of water is possible by a proper grading of the surface and by bricking the main distributaries. In the case of wheat, a yield of 18 maunds 30 seers per acre was obtained on an area of about three acres with one irrigation only. This was applied before sowing in October so as to ensure a good germination. Afterwards the soil moisture was conserved by means of a surface mulch produced by lever harrows. The ordinary yield of irrigated wheat near Quetta is not much over twenty maunds per acre and the usual number of waterings

is six to eight. The great saving of water possible by the use of a surface mulch in the case of a wheat crop is therefore obvious.

The growth of Persian clover (*shaftful*) as a green manure at Quetta continues to give excellent results. When sown in August, this crop gives three cuts of green fodder weighing about 60,000 lbs. per acre before the end of the following May. In addition, the last cut is either ploughed in as green manure or a crop of seed is raised. A marked improvement in the water holding capacity and tilth of the soil follows this treatment. A small amount of seed was distributed during the year and arrangements are being made to raise a large quantity this summer.

The investigations, referred to in the previous report, on the yellowing of peach trees have resulted in the discovery of the cause and of an easy method of prevention. In the vegetable gardens in the Civil Station of Quetta the peach trees have, as a rule, very yellow foliage, often accompanied by excessive gumming. Such trees die very quickly and do not bear a large crop once the unhealthy symptoms are well marked. The early symptoms appear to be identical with the disease in the Eastern United States known as " Peach yellows." The later symptoms of the disease, namely, premature reddening and ripening of the fruit, are however not developed. The yellow condition is not propagated by buds taken from affected trees and thus the disease is not the " Peach yellows " of the United States. Applications of soluble nitrogenous manures, such as nitrate of soda or sulphate of ammonia, gave negative results, so that want of available nitrogen is not connected with the trouble. It was found that if *shaftal* is grown round the affected trees the disease slowly disappears and the trees produce healthy growth. This result suggested that the yellowing of the foliage is due to want of air in the subsoil which follows the system of surface irrigation without any subsequent cultivation now in use at Quetta. During the present year this opinion has been confirmed. Some of the peach trees at the Fruit Experiment Station were over-irri-

gated by surface flooding during March and April last and by the beginning of May the new foliage showed the characteristic yellow tinge. Irrigation was stopped and the soil round the trees was well cultivated right down to the roots. In less than a fortnight the yellowness disappeared and the trees now show the characteristic shiny green foliage of vigorous growth. By growing the *shaftal* in beds between the lines of peach trees and by keeping the strip of soil, in which the trees occur, well cultivated the relations between air and moisture in the soil most suitable for the peach can be maintained. After the buds open in March the trees should only occasionally be watered directly as the roots get sufficient water when the beds of *shaftal* are irrigated.

The sale of improved fruit boxes to the public and the trade was continued during the year. These are now in general use at Quetta and during the present summer it is hoped to complete the experimental work on this subject and introduce several more improved packages.

During my absence on leave in 1913, Colonel Duke, I.M.S., Residency Surgeon and Chief Administrative Medical Officer in Baluchistan, kindly agreed to inspect the work from time to time and to give any necessary advice to the Assistant in Charge. This arrangement proved most useful.

V.—Programme and Publications.

Programme of work for 1914-15.

Plant breeding and plant improvement.—Work will be continued on the following crops on the lines indicated in the annual reports and in the publications of the section—wheat, tobacco, gram, fibre plants, indigo, oil seeds and fruit.

Publications.

Very little progress was made during the year in the publication of results. This part of the work is now in arrears, but a special effort is being made this summer to bring the publication of results up to date.

The following papers were published during the year :—

1. The Improvement of Indigo in Bihar (with G. L. C. Howard). Published by the Bihar Planters' Association.
2. Soil Denudation by Rainfall and Drainage. The Conservation of Soil Moisture. *Quarterly Journal, Indian Tea Association*, Part I, 1914.
3. The Seed Supply of the New Pusa Wheats (with G. L. C. Howard). Reprinted in the *Agricultural Journal of India*, Vol. IX, Part III, 1914.
4. Notes on Drainage and Green Manuring (with G. L. C. Howard). *Agricultural Journal of India*, Vol. IX, Part II, 1914.

REPORT OF THE IMPERIAL MYCOLOGIST.

(F. J. F. SHAW, B.Sc., A.R.C.S., F.L.S.)

I.—CHARGE AND ESTABLISHMENT.

Dr. Butler held charge of the section until 28th March 1914, when he proceeded on privilege leave and furlough; since this date I have been in charge of the section. I was absent on duty in Madras up to 31st October 1913, when Mr. McRae, Government Mycologist, Coimbatore, returned from leave.

S. Pasupati Iyer, second clerk, resigned to take up the Sericultural course on 22nd November 1913, and Nripendra Chandra Sen filled the vacancy thus caused until 26th March 1914, when Md. Taslim was appointed. All the staff have worked well.

II.—TRAINING.

Mr. A. C. Tunstall, Mycologist to the Indian Tea Association, worked in the laboratory as a visitor for about a week in September and Mr. G. H. Alington, I.F.S., Assistant to Forest Botanist, was deputed to study some tree diseases in January. Babu B. L. Gupta, B.Sc., Professor of Biology in the Reid Christian College, Lucknow, attended the laboratory during May and June and received a course of lectures and practical work on the morphology of the fungi.

III.—DISEASES OF PLANTS.

The investigation of the diseases of crops, the collection and identification of Indian fungi, and the giving of advice to cultivators and officers of the Department formed the principal work of the section.

(1) *Paddy Disease.*—The most serious disease of paddy is that which is known in Eastern Bengal as "ufra." An account of this trouble has been published in

Bulletin No. 34 of the Department while popular descriptions have appeared in the *Agricultural Journal of India* and in a Bengali leaflet. It has been established that the organism responsible for the damage is a form of eelworm (*T. angustus*) belonging to the genus *Tylenchus*, of which several species are known to cause serious diseases of cereals. Inoculations with material which, so far as could be determined, contained no other constant organism but the worm, have been successful in producing typical "ufra" in localities where the disease was quite unknown. The disease commences its ravages in July and culminates about September-October when large numbers of motile worms are present. After December they remain immotile and dormant in the dry grains and probably recommence activity only with the flooding of the fields after sowing; in this connection experiments have shown that *T. angustus* can withstand desiccation for even 15 months. It is a curious fact that transplanted paddy appears to be comparatively immune to natural attack. During the present year efforts have been made to map out the extent of the infected area and an experiment is in progress at Comilla to test remedial measures. It is probable that burning the stubble on the soil after winter harvest will be found to be the most efficient means of combating this disease. The infected area in Eastern Bengal appears to stretch from the Madhupur jungle north of Dacca to the river Mahari in Chittagong District. Westward the disease is bounded by the Padma but the eastern limit is uncertain, the infected area almost certainly reaches to the Meghna and further search is needed in the direction of Sylhet. In Tippera the northern limit of infection is near Akhaura on the Assam-Bengal Railway and the disease is particularly virulent in this district at Narjanpur, Comilla and Chandpur, at Begumganj and Chaumuhani in Noakhali District, and also at Fenni in Chittagong District. The most important fact in the distribution of this disease is that it has recently been identified with the "sanhra" condition of paddy in the Khunti Sub-Division near

Ranchi; further investigations will be carried out in this area.

The losses caused by "ufra" are very heavy. In Begumganj thana in 1910 the loss was estimated at 200,000 maunds of grain and in Chaumuhani in 1911 nearly half the winter crop was lost. The supreme importance of paddy as a food crop in Bengal and the virulence of this disease will make it the major work of this section for some time to come.

An account of *Sclerotium Oryzæ* Catt. was published as a memoir of the Department. This fungus has been found attacking rice in Burma, in Madras, and also in Bihar and Orissa, in which latter province it has been collected at Cuttack, at Pusa and near Ranchi. Paddy infected by this parasite usually shows excessive tillering and lightness in the grain, in fact there is frequently nothing within the glumes. In culture the morphology of the fungus proved more or less dependent upon the nature of the nutrient medium. The observations of Cattaneo, who regarded the sclerotia as spore containing organs, were not confirmed in the present memoir.

Brief accounts of Rice Bunt (*Tilletia horrida* Tak.) and False smut [*Ustilaginoidea virens* (Cke.) Tak.] were published in *Bulletin* No. 34. The former has been the cause of complaints from Germany, its spores having been found in rice imported from Burma and Siam. Effective remedies for this type of disease are known, should the trouble become severe.

(2) *Sugarcane disease.*—Complete accounts of the principal diseases of this crop were published during the year as memoirs of the Department.

"Red rot" has been the subject of previous publications of this section. In the most recent communication the authors have worked out the mode of air-borne infection in the field, a point which had long been obscure. It was found that infection took place chiefly at the adventitious root eyes, although penetration was also easy at the shoot

buds. The chief source of infection was the form of *Colletotrichum falcatum* which occurs on the mid ribs of leaves. The process of sett selection, described in previous publications, offers the best method of combating this disease. In districts where the local cane is badly diseased a fresh healthy type of cane should be imported and setts inspected carefully each year before planting. Fortunately in India we have a large range of these canes of hardy habit and great tillering power, which are relatively immune to red rot, and it has been found possible by hybridisation to combine the characters of such canes with those of the thicker, heavier yielding varieties of other countries. The introduction of new and immune varieties of cane has been very successful in Bombay Presidency. The Imperial Mycologist visited Surat in October last and concluded that while the present state of the cane was good an outbreak of disease must be expected unless there is a marked improvement in local cultivation. At present the canes are grown in low lands and are practically waterlogged. The adoption of the Godavari trench system or the nursery system of cultivation common in Ganjam is recommended.

The wilt disease of sugarcane was found to be due to the attack of *Cephalosporium Sacchari* Butl., a hitherto undescribed species. This disease strongly resembles " red rot," but in the case of infection by air-borne spores the plant was found to be far more susceptible to infection at stem wounds than in the previous case. The disease has been found at Surat, Poona, Samalkota and throughout North-eastern India. The control of the trouble should be on the same lines as in true red rot. As, however, wound infection is more common, the importance of removing diseased clumps before they have time to rot and set free spores is much greater. It is probable that this disease is incapable of doing permanent damage so long as the measures advocated against red rot, which are essential to the successful growing of thick cane in Northern India, are carried out.

" Collar rot " of sugarcane is due to the attack of *Hendersonina Sacchari* Butl., a hitherto undescribed genus. The outward symptoms are a withering of the top and a black rot of the roots; the lower nodes show a red discoloration in the pith. The roots and the base of the stem are full of the hyphæ of the fungus from which cultures are easily obtained. Both in cultures and on diseased canes a pycnidial stage was observed; the pycnidia are peculiar in containing two types of spores in the same loculus. Inoculations with pure cultures of the fungus were carried out at Samalkota and were successful in producing the disease. This disease occurs at Samalkota and at Jorhat; the extent of the damage caused by it is unknown.

Helminthosporiose of sugarcane is due to the well known genus *Helminthosporium*, of which *H. Sacchari* Butl. is a new species. This fungus is common on the leaves of sugarcane in Pusa where it produces small red discolorations. Inoculations with pure cultures were successful. The damage done by this disease is at present negligible.

Smut of sugarcane (*Ustilago Sacchari*) has been under observation in the Central Provinces and culture work with this fungus is now in progress at Pusa. " Sereh " of sugarcane was reported at Jorhat and Coimbatore during the year. The Imperial Mycologist visited Coimbatore in October last and satisfied himself that " sereh " disease was not present.

(3) *Palm diseases.*—During the year an outbreak of bud rot took place among the coconut palms of Malabar. The disease was investigated by the Supernumerary Mycologist, who was at that time officiating as Government Mycologist, Madras, and proved to be due to *Pythium palmivorum* Butl., the cause of the palmyra palm disease in the Godavari district. The fungus was studied in pure culture for the first time and inoculations were successfully carried out. It was found that the fungus was particularly active in producing rows of spots on the young leaves

of coconut palms. From such infections the fungus reaches the central bud by means of motile zoospores being washed down the leaves. Once the soft white leaf bases are reached a virulent rot takes place leading to the death of the tree. As the result of numerous observations on the discharge of zoospores it was concluded that the fungus probably belongs to the genus *Phytophthora* and not to *Pythium*.

Active measures, on the lines of those in operation in the Godavari, have been taken against the disease by the Government of Madras. A popular account of this trouble has been published in the *Agricultural Journal of India* and the more scientific results have appeared in the *Annales Mycologici*.

A "collar rot" of areca palms has been identified in Sylhet and Khulna and is probably due to *Fomes lucidus* (Leys) Fr. This fungus also occurs on *Guazoma* and pure cultures have been obtained from this source by Mr. Hafiz Khan. Inoculations have shown that the fungus is a true parasite on *Guazoma* and work is being continued on the areca palm.

(4) *Rhizoctonia*.—In January last there was a bad outbreak of disease on Pusa Farm due to this fungus. The crop affected was chiefly mustard, but the parasite was almost omnivorous. The fungus was *Rhizoctonia Napi* West—a species not previously observed in India. It is under observation in pure culture; it appears to be incapable of growth at the temperature of the hot weather and rains in Pusa.

A rot of stored potatoes at Sabour and Bankipore was also due to *Rhizoctonia*. The species *R. Solani* Kühn was common and in one case a very bad rot was identified as due to *R. destruens* Tass. The latter fungus was also a virulent parasite on *Delphinium* at the Alipore Horticultural Gardens, Calcutta; in fact it was its occurrence on this plant which enabled it to be identified on the potato.

At the beginning of the year numerous specimens of diseased poppy plants were received from the officials of the

Opium Department in the United Provinces. The specimens were infected sometimes by *Rhizoctonia* and more rarely by *Peronospora arborescens* (Berk.) de Bary. I visited Basti in March and concluded that the diseased condition of the poppy crop was due rather to the practice of keeping certain fields under poppy year after year than to any parasitic infection. The fungi found on the plants are a symptom rather than a cause of the condition of the crop. Investigation will be continued next season.

(5) *Cotton and Sesamum wilts.*—An attempt was made to define the southern limits of extension of cotton wilt, which the previous year had been traced from the Central Provinces to Belgaum. It was found to be present very sporadically in Bellary District, presumably as an extension from the Dharwar side, but a careful search at Guntakal in Anantapur District and Nandyal in Kurnool District failed to show any trace of the disease. As no reports of its occurrence elsewhere in Madras have been received, it may be assumed that only the extreme north-west of the Presidency has been reached. On the other side typical cases have been received from the Nadiad Farm near Ahmedabad though the disease appears to be little prevalent in Gujarat. Cotton wilt is, therefore, present in the western part of the Central Provinces, practically the whole of Bombay, exclusive of Sind, and the north-west corner of Madras. It is severe in parts of the Berars and threatening in parts of Khandesh, but elsewhere, at present, does little damage. The cause was definitely established during the year to be a species of *Fusarium*, successful inoculations with pure cultures of the fungus having been secured. Through the kindness of the United States Department of Agriculture an opportunity was obtained of comparing the Indian cotton wilt fungus with *Fusarium vasinfectum* Atk., the organism which is the cause of cotton wilt in America. There are considerable differences between the two parasites and it is probable that the Indian fungus is a distinct species. It is also probable, though accurate information on this point is

not yet available, that the Indian disease is decidedly less virulent than that in the United States. India is fortunate too in possessing a race of cotton, " buri," which is absolutely immune to the disease. Arrangements have been made, through Mr. Clouston, Deputy Director of Agriculture, Central Provinces (to whom the discovery of this property of " buri " cotton is due), to supply seed of this variety for trial in the United States in wilt infected tracts, and in return we are to receive American wilt-resisting varieties for trial in India. There is no other known method of fighting *Fusarium* wilts but by the growth of immune or resistant varieties.

Sesamum wilt has also been proved to be due to a *Fusarium*, and cross inoculations have confirmed what was already probable from morphological study, that the cotton and sesamum diseases are distinct and are due to different species of *Fusarium*. It is, in artificial inoculations, a much more virulent disease than the cotton wilt, proving fatal in every case tried—several hundreds. No resistant variety is known, but the cold weather (*rabi*) crop is less subject to the disease than the monsoon (*kharif*) varieties. Further work on these diseases will be resumed when opportunity arises.

(6) *Phytophthora investigations.*—The potato blight due to *Ph. infestans* (Mont.) de Bary, was investigated by Mr. J. F. Dastur, First Assistant. It was discovered that the fungus does not survive in the heat of the plains of India and is not therefore likely to become a serious pest, except possibly in the hills. A species of *Phytophothora* has also been discovered attacking *Vinca* and *Petunia;* it is a variety of the *Ph. parasitica* on castor which has been the subject of a recent memoir. The slight variation in measurements and a few differences in the inoculation experiments may be accounted for by the influence of the host plant.

(7) *Anthracnose.*—This disease has been investigated upon the betel vine, plantain, chilli and papaya. In the case of the betel vine the perfect stage of the species of *Colletotrichum* has been discovered to be an Ascomycetes

and the *Colletotrichum* and *Glœosporium* upon chilli have been proved to be one and the same fungus. The most important feature of the work on this crop is that the disease appears to be transmitted through the seeds. Various methods of seed treatment will be tried during the current year and experiments will also be conducted in the spraying of plantains against anthracnose.

(8) *Groundnut leaf disease.*—The relation between the incidence of the *tikka* disease of groundnut and the amount of cultivation and export of that crop was the subject of an inquiry during the year under review. Between 1894 and 1902 the export of groundnuts fell from 78,488 tons to 2,890 and the trade became practically extinct. The fall in the exports was due not to any deterioration in the quality of the produce, but to a marked decrease in the yield per acre, which appeared to be the result of a fungal disease, known locally as *tikka*. Treatment with fungicides had no effect in stopping the disease and, in 1902, the Bombay Department of Agriculture commenced the introduction of exotic varieties. These varieties were also attacked by *tikka*, but some, which ripened early, did not have their yield appreciably affected. Two varieties from Japan were especially useful in forming their nuts before the disease was sufficiently established on them to damage the produce. As a result of this, the exotic varieties, introduced by the Bombay Department of Agriculture, have now replaced the indigenous in all districts except the Poona district. Moreover by 1912 the *tikka* disease had decreased to such an extent that, in the whole Bombay Presidency, diseased specimens could only be obtained on the Manjri Farm. Coincident with the introduction of exotic varieties and the decrease in the amount of *tikka* disease the exports began to rise. In 1902 they were 2,890 tons, in 1906 they were 6,527 tons, in 1909, 23,934 tons, and in 1912, 48,801 tons. This is probably one of the most marked cases on record where a crop disease has been checked and a trade rejuvenated by the introduction and acclimatisation of new varieties.

(9) *Other plant diseases.*—A trial was made of the hot water treatment, which is so useful in the case of oat smut, against smut of bajra; the treatment proved useless. The treatment of oat smut by formaline steeping was successfully demonstrated on several estates in Bihar. Investigations into phanerogamic parasites and in particular the influence of chilli saltpetre on *tokra* of tobacco were resumed.

IV.—Systematic Work.

There were 505 additions to the herbarium during the year under review. Of these new additions we are indebted to the Bureau of Science, Manilla, and to mycologists in Berlin for 269 species. Named collections of Indian Fungi were sent in exchange. Collections of fungi for naming were received from, and duplicates were issued, if required, to the Mycological Officers of Provincial Departments of Agriculture and the Curator, Royal Botanic Gardens, Calcutta.

The systematic study of the large collections of *Deuteromycetes* (*fungi imperfecti*) in the Herbarium was taken up and material obtained for a fifth part of the *Fungi Indiæ Orientalis;* the series is being published in collaboration with H. & P. Sydow, Berlin.* At least one other part will be required to finish this large group.

A short paper was published describing the complete stages of the rusts of sugarcane, figs and *Oldenandia.*

V.—Miscellaneous.

The Imperial Mycologist attended the Board of Agriculture in December and the centenary celebrations of the Indian Museum in January. Assistance was given to the Imperial Bacteriologist in the identification of a fungus isolated from bursati tumours and in an inquiry into the relationship of fungi parasitic upon fodder to certain cattle diseases. In collaboration with the Imperial Agricultural Bacteriologist an examination was conducted

* This work will perforce stop during the war.—F. J. F. S.

on the fungi concerned in the fermentation of rice in the production of indigenous beer. The chief fungi present were *Mucor Prainii* Nech., *Mucor javanicus* Wehm., *Cladosporium Chodati* (Nech.) Sacc., *Rhizopous Cambodja* (Chrz.) Vuill.

VI.—Programme of work for 1914-15.

(1) *Research and experimental work.*—The investigation of some diseases of rice will be continued. The present stage of the investigations is given in *Pusa Bulletin* No. 34, 1913 " Diseases of Rice " and *Memoir, Botanical Series* VI, No. 2, 1913 " A sclerotial disease of Rice." The work will be continued particularly with a view to filling up gaps in our knowledge of the life-history of the organism which causes " ufra " disease, to the explanation of the apparent immunity of transplanted paddy to this disease, and to testing methods for its control. An obscure diseased condition of rice, known in parts of Bihar as " chatra," will be studied. Both these are major investigations. With regard to the other diseases of rice, none appear at present to be of great practical importance, and the investigations will be confined chiefly to the life history of the parasites concerned.

The investigation of the fungus diseases of sugarcane will be continued. Two *Memoirs* (*Botanical Series* VI, Nos. 5 and 6) containing the results of the work up to date, were published in 1913, and deal with the methods of infection and control in red rot of sugarcane, and with the symptoms and cause of three undescribed cane diseases, two of which have been sometimes confused with red rot. Future work will, for the present, be considered as of minor importance and will include a more detailed study of one of these diseases, " collar rot," and its connection, if any, with the sereh-like degeneration of cane known in several parts of India, and also the extent to which soil infection occurs in red rot.

The study of the wilt disease of cotton and sesamum will be continued on the lines described in *Memoir,*

Botanical Series II, No. 9 " Wilt disease of Pigeon pea." No results of sufficient interest to justify publication have yet been gained in connection with these diseases, which are of sufficient importance to be considered as amongst the major diseases of crops in India.

The work on potato blight recently commenced may also require to be treated as a major investigation if the disease recurs in the Gangetic Plain, where there was a severe outbreak last year. It is hoped to study the growth of the parasite in artificial culture and in particular to investigate its temperature relations as it is in this direction that its control appears to be most hopeful. As minor investigations the study of some allied parasites will be undertaken. Two of these have been studied in detail and the results published as *Memoirs, Botanical Series* V, Nos. 4 and 5, 1913, since the submission of the last programme to the Board.

The opium poppy blight has usually been believed to be caused by an allied fungus to the last mentioned group, but evidence was obtained last year, when the disease was severe, which suggests that this is not the case, but that the cause is a species of *Rhizoctonia.* The investigation of this disease will be directed to ascertain the true cause and to test methods of control. The study of other diseases caused by *Rhizoctonia* will be continued as occasion arises, and as sufficient material has been accumulated to undertake a more detailed study of this genus, it will be considered a major investigation.

The study of certain green parasites of crops will be continued. Little is known of these parasites in India and it is of importance to investigate their biology, particularly with reference to possibilities of checking the damage caused by them. The investigation has only recently been commenced and has not yet given any definite results.

Some preliminary work on soil fungi has been commenced and it is hoped to develop this as time permits, particularly with a view to elucidate the action of

fungi in assisting in the decomposition of organic matter. The subject may prove of interest in connection with green manuring, but it is not possible, as yet, to indicate on what lines it will develop.

A number of minor investigations of diseases of crops and fruit trees are in progress or projected. New work of this nature continually arises and it depends on the time available for their study and the relative importance of the disease as to whether they become major or minor items of the work of the section.

(2) *Training.*—This will be continued on the lines indicated in the Prospectus. Short courses will also be given if any students of the Institute wish to attend.

(3) The routine work of advising on plant diseases will be continued and assistance will be given as usual to Provincial Departments of Agriculture, the Forest Department, Planters' Associations and the general public.

(4) It is hoped to make further progress with the publication of descriptive lists of Indian fungi in the series "Fungi Indiæ Orientalis," of which four parts have already been published in collaboration with Messrs. H. & P. Sydow of Berlin, and a fifth is in preparation. The extension of this series to include the groups not yet dealt with is the most important part of the systematic work of the section and is very necessary. Minor papers on systematic mycology will also, probably, be published.

VII.—Publications.

Butler, E. J. . . . Ufra disease of Rice. *Agri. Journ., India,* VIII, July, 1913 (also Bengali translation).

Butler, E. J. . . . Diseases of Rice. *Bull. Agri., Res. Inst., Pusa,* No. 34, 1913.

Butler, E. J. . . . *Tikka* disease and the introduction of exotic groundnuts in Bombay Presidency. *Agri. Journ., India,* IX, January, 1914.

Butler, E. J. . . . Notes on some rusts in India. *Annales Mycologici,* XII, 1914.

Butler, E. J. . . . Report on Mycology for 1912-13 for Board of Scientific Advice.

Butler, E. J., & A. Hafiz Khan. Red Rot of Sugarcane. *Mem. Dept. of Agri., India*, Bot. Ser. VI, No. 5, October, 1913.

Butler, E. J., & A. Hafiz Khan. Some new Sugarcane diseases. *Mem. Dept. of Agri., India*, Bot. Ser. VI, No. 6, December, 1913.

Butler, E. J., & Saccardo, P. A. Fungi Indici. *Annales Mycologici*, XII, No. 3, 1914.

Shaw, F. J. F. . . Sclerotial disease of Rice. *Mem. Dept. of Agri., India*, Bot. Ser. VI, No. 2, July, 1913.

Shaw, F. J. F. . . The Mahali disease of Areca-nuts. *Leaflet No. 7 of 1913 of the Dept. of Agri., Madras.*

Shaw, F. J. F., & McRae, W. The Bud Rot of Coconuts in the Malabar District. *Leaflet No. 10 of 1914 of the Dept. of Agri., Madras.*

Shaw, F. J. F., & S. Sundararaman. Bud Rot of Coconuts in Malabar. *Agri. Journ., India*, April, 1914.

Shaw, F. J. F., & S. Sundararaman. Bud Rot of Coconuts in Malabar. *Annales Mycologici*, XII, No. 3, 1914.

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REPORT OF THE IMPERIAL ENTOMOLOGIST.

(T. Bainbrigge Fletcher, R.N., F.L.S., F.E.S., F.Z.S.)

I.—Charge and Establishment.

Mr. H. Maxwell-Lefroy resigned his appointment as Imperial Entomologist from 1st December 1912 and I was nominated to succeed him and my services were transferred to the Government of India from that date but I was retained temporarily in Madras until relieved there, so that it was not until 1st December 1913 that I actually took over charge as Imperial Entomologist. Mr. A. J. Grove, Supernumerary Entomologist, who was in temporary charge of the section pending my return from Madras, was lent to the Punjab from 27th January 1914 to carry out work on grain pests and cotton bollworm, and remained in the Punjab until the close of the year under report. Mr. C. S. Misra, First Assistant, was on duty throughout the year and has carried out his work in a uniformly satisfactory manner; he has given his attention especially to the examination and record of the crop-pests of the cultivated areas of the Pusa Estate, to the collection of information regarding fruit-pests, and to the study of cotton bollworms and their parasites, of *Pyrilla* and of *Aleurodidæ*. Mr. C. C. Ghosh has been employed in the usual routine work of the rearing of insects in the Insectary. Mr. G. R. Dutt, as in previous years, has looked after the economic records and the *Hymenoptera* Collection. Mr. D. Nowroji has looked after the General Collection of Insects, especially the *Coleoptera*. The duties of these two assistants must naturally tend to increase considerably every year as the collections and records are augmented. Mr. M. N. De is borne especially for Sericultural duties and has been in charge of the silk work during the year and has carried out his duties with zeal and intelligence.

II.—Training.

Two students were under training in General Entomology during the year; one came from Travancore and completed his course on 30th September 1913, the other from Assam finished his training on 31st October 1913. No students are now under training; one man was to have been sent by the Punjab in June 1914, but it is understood that his course has now been postponed for a year. As all the provinces have now got a staff of trained assistants it is obvious that only occasional students are likely to be received at Pusa for training in Entomology, as there is no sign of any demand for a knowledge of this subject for its own sake and except as a means for Government employment. The lack of demand for training has, however, this advantage, that the Pusa staff is able to devote more time to research work.

III.—Tours.

I was away from headquarters in Madras from 1st December 1913 to 8th January 1914, attending the meeting of the Board of Agriculture and going over collections and records at Coimbatore. On 6th March I went to Nagpur to examine the Agricultural students in Entomology and returned on 15th March. On 22nd March I left Pusa again for Madras to examine the students there and to get in touch with the new Government Entomologist. I also visited Ceylon to see the local arrangements regarding plant imports and Coorg to see the extent of spread and control of the green scale on coffee, and returned through Bombay to see the entomological work there, arriving back at Pusa on 8th June. During this tour I also saw the Customs Officials at various ports which have been proposed as entry ports under the new Pest Act, and collected considerable information regarding plant imports into India. Mr. Grove toured in the Punjab from 8th August to 13th September, and visited Sabour in October and Siripur in November. Mr. Misra was sent on special duty to Karauli State from 2nd November to 6th December to establish the Lac Industry there; he also toured in Madras, Bombay and

the Central Provinces from 25th January to 12th March with the especial object of obtaining information on pests of fruit-trees. Mr. Ghosh visited Darjiling and Naini Tal in September to see the methods of bee-keeping practised there. Mr. De visited Assam in February to obtain information regarding Eri and Muga silkworms.

IV.—Provincial Work.

The entomological work of the Provincial Departments of Agriculture is to a large extent supplementary of and interdependent on that done at Pusa. Except in Madras, none of the Provincial Entomological Assistants are placed under the control of a qualified expert able to check their work locally and under such circumstances a Central Institute can fulfil a very useful function in checking and correlating their work besides acting as a centre for information regarding life-histories, records of occurrence and means of control of insect pests. Some provinces have taken full advantage of this fact in the past and have worked in close touch with Pusa; others have not done so hitherto, but it is hoped that, as a result of efforts now being made, they may do so in future.

In Madras the Deccan Grasshopper work was continued in the Bellary District but the failure of the rains at the commencement of the monsoon caused the destruction by drought of the early-sown crops in the area attacked so that the control-operations proved abortive on this account. The Entomological Laboratory fittings and the Insectary at Coimbatore were completed during the year and the collection rearranged in the new boxes. A large amount of information on insect pests was amassed and much of this was utilised for a book on South Indian insects which was written and completed by myself before leaving Madras. My successor, Mr. E. Ballard, who had been Government Entomologist in Nyasaland for the preceding two years, joined his new appointment at Coimbatore in January 1914 and has since been engaged in familiarizing himself with the insects of the Madras Presidency.

In Bombay there are now only two Entomological Assistants employed, one as Lecturer in the Agricultural College at Poona, the other in the Northern Division of the Presidency. The Third Assistant, who was stationed at Dharwar in the Southern Division, has been transferred to the Agricultural Section and his post has not been filled. Special attention has been paid to the occurrence and control of *Schœnobius bipunctifer*, which is a serious pest of rice.

In the Central Provinces two Entomological Assistants are employed, one for teaching at the Agricultural College at Nagpur, the other for fieldwork and demonstration. The latter made numerous notes on insect pests and exhibited show-cases and lectured and demonstrated control-methods at numerous Agricultural shows to audiences aggregating about nine thousand cultivators. Large numbers of *Canthecona furcellata*, a Pentatomid Bug predaceous on caterpillars, were bred and liberated in cotton and gram fields to check attacks on these crops by caterpillars.

In the United Provinces, demonstration was made in the Farrukhabad District of methods of storing seed potatoes to avoid attack of the Potato Moth (*Phthorimœa operculella*) which is now widely distributed in these provinces, though as yet it has apparently not reached the Hill Districts.

In the Punjab the work done has mainly been on pests of cotton and stored grain. Living specimens of *Rhogas*, a Braconid parasite of the cotton bollworm (*Earias*), have been supplied from time to time from Pusa.

In the North-West Frontier Province one Entomological Assistant works under the Agricultural Officer. The sugarcane crop is reported as badly infested with borers this year, over 50,000 egg-clusters having been picked from one experimental plot of six acres. *Gelechia gossypiella* is stated to have done considerable damage to last year's

cotton crop, but it is observable that late-ripening varieties were attacked most severely, local cotton (*Gossypium neglectum*), which ripens and is picked before the middle of October, practically escaping attack. Living specimens of *Rhogas* were supplied from Pusa and set free in the cotton-fields of the Agricultural Station at Tarnab, but it is doubtful whether they have established themselves. A Jassid bug, attacking grape-vines in the vineyards situated in the lower parts of the Peshawar Valley, has also been under investigation.

In Bihar the entomological work has always been done in close touch with Pusa and this has been the result of policy rather than of the contiguity of the two localities. An account of the more important pests was prepared some three years ago and was issued at the close of the year under review as a Crop-pest Handbook. The most important work undertaken has been the control of *Agrotis ypsilon* on the Mokameh Tal and the storage of potatoes. At Mokameh a regular campaign was undertaken and during the season 39,000 caterpillars were picked and destroyed on the high lands, whilst 34 traps destroyed 893,320 moths of which about 41 per cent. were females. On account of abnormal flood conditions and other factors, the attack was unusually serious, some 5,000 bighas of *rabi* pulse crops being destroyed. A similar campaign was undertaken against the same insect for the first time at Colgong and Ghogha, where 21 traps destroyed 43,874 moths whilst 337,600 caterpillars were handpicked from the high lands which were first attacked; the attack, which normally extends over an area of 8,000 bighas, was reduced to a nominal damage over about 20 bighas as a result of the above-mentioned efforts. The storage of seed potatoes has of late years presented great difficulties in Bihar, as in other provinces, as a result of the introduction into India of the Potato Moth (*Phthorimæa operculella*). Storage under dry sand has proved fairly effective in the districts South of the Ganges and Government godowns were started at Bihar, Bhagalpur, Colgong and Sabour in order to demonstrate the practicability and

advantages of this method. Storage was done satisfactorily in all these places and the method of storage is becoming popular amongst the cultivators and others interested. That this method is actually being adopted is shown by the fact that at Patna and Bihar in 1913 no less than 1,520 persons stored 122,285 maunds of potatoes under sand, as compared with 16,613 maunds stored by 399 persons in 1912, and 8,000 maunds by 200 men in 1911. Another pest of stored potatoes in Tirhut is a Tingidid bug (*Recaredus* sp.) and experiments are being made to find a successful method of control, as sand-storage is found to induce rotting of the potatoes in the damp climate of Tirhut.

In Bengal the Entomological staff only includes one Collector who is employed under the Government Botanist. He was chiefly occupied in dealing with pests of rice and also attended the Agricultural shows at Barasat, Khulna, Suri, Brahmanburia and Kamarchar where he explained insect pests and their life-histories and demonstrated the use of control methods.

The Entomological Assistant in Assam only went to his province in November 1913 after completion of his training at Pusa.

In Burma there is one Entomological Assistant, who was chiefly employed on the collection of information regarding insect pests of rice.

V.—Work at Pusa.

Investigation into the life-histories of injurious and other insects was continued, the following insects being those of which at least complete life-cycles were obtained :—

Pyrilla aberrans.
Aleurodes bergi and *A. citri.*
Atractomorpha crenulata.
Eublemma olivacea.
Odoiporus longicollis.
Virachola isocrates.

An unidentified Dermestid beetle on Stored Wheat.
Harpactor costalis.
Canthecona furcellata.
Syntomis cyssea.
Taragama siva.
Polyocha saccharella.
Dolycoris indicus.
A Psocid on *Loranthus.*

Figures of the various stages of most of these insects have been drawn and will be utilized for Memoirs on the insects concerned.

The subject of natural enemies (parasites and predators) of crop-pests is of great importance in India and a start is being made to collect information on the subject. Special attention has been paid to the parasites and hyperparasites of cotton bollworms (*Earias* spp.), of *Achæa melicerta* and of *Pieris brassicæ.* Parcels of *Earias* larvæ parasitized by *Rhogas lefroyi* were sent to the North-West Frontier Province and the Punjab to endeavour to assist control of this pest. There is no doubt that in the near future such control-methods will be found to be applicable in many cases, especially in the case of introduced pests, and we are already receiving numerous inquiries from abroad (notably America and Italy) regarding parasites of destructive crop-pests, and an attempt is being made to procure a parasitized colony of *Aleurodes citri* for export to Florida where this insect has done vast damage to the orange industry. In this connection it is of interest to note that an apparently identical parasite has also been reared from *Aleurodes ricini,* which occurs commonly on Castor in India, and specimens of the two parasites have been sent to Washington for exact determination, as their identity, if established, will be of practical importance.

Attempts have been made to trace *Agrotis ypsilon* through the hot weather and rains, as it is not known in what stage the insect passes this period on the Mokameh Tal, if it is actually present then at all. Incidentally, in

collecting the larvæ, it was found that they are preyed upon extensively by a Carabid beetle (*Broscus punctatus*).

The study of insects affecting stored grain was continued by the Supernumerary Entomologist, and the life-histories of *Æthriostoma undulata*, *Tribolium castaneum* (*ferrugineum*), and *Rhizopertha dominica* have also been worked out by Mr. Nowroji.

Special attention has also been paid to the insect pests of paddy and sugarcane, and large numbers of insects have been bred out and their study will be taken up when sufficiently long series are secured both from Pusa and the provinces. It may be noted here that paddy stubble, collected in the fields at Pusa in February, showed that about forty per cent. of the stalks contained borers.

Work on Termites has been continued and determinations of upwards of four hundred lots of these insects were received from Professor Nils Holmgren, of Stockholm; the identification of this material not only increases by some twenty species the list of known Indian forms, but will prove of great assistance in the discrimination of the various kinds found to do damage and in the writing up of a large accumulation of notes on their bionomies and occurrence. Wood treated by various processes was examined in February 1914 and some of the pieces of Powellized wood were found to be attacked by *Microtermes obesi* (*anandi*). This process is therefore not so infallible as has been claimed. Examination of some of the other series indicated that exemption from attack depends on the variety of the wood itself as well as on the method of treatment and in addition to the preferential tastes shown by the various species of termites locally prevalent; this point scarcely seems to have received proper consideration hitherto and it is proposed to initiate further series of experiments.

The green scale, *Coccus viridis* (*Lecanium viride*), which has proved such a serious pest of coffee in Ceylon and Southern India, first invaded Coorg in 1913 and bids fair

to become a serious pest there also. In May 1914 I visited Coorg, saw the affected areas and advised the planters on the subject. The scale was found to be parasitized to a very slight extent by a minute Chalcidid, apparently a species of *Coccophagus*, which has been sent to Washington for exact determination.

A consignment of *Microsporidium polyhedricum* in dead silkworms was received from the Government Entomologist, Egypt. This organism is said to be effective in the control of *Prodenia litura* in Egypt, but experiments at Pusa, conducted with the help of the Imperial Agricultural Bacteriologist, gave negative results with silkworms and larvæ of *Prodenia litura.*

An event of the year which deserves mention in this report is the passing of the Insect Pests Bill (Act II of 1914) for controlling the importation into British India of living plants which might otherwise bring in noxious insects in the future as they have done in the past. A Notification has been issued regarding certain specified crops, but this is aimed rather at the importation of fungal diseases, and a second Notification will doubtless be issued regarding all plants which are likely to bring in insect pests.

Under the Wild Birds and Animals' Protection Act, 1912 (Act VIII of 1912), a Notification regarding the protection of certain useful species of Wild Birds has been issued by the Governments of Bihar and Orissa and Madras, but I am not aware that any other Local Government has as yet issued a Notification under the Act.

Silk.—Six students completed a short course in Eri and Mulberry silkworm rearing. Besides these, Mr. Ayoob Ahmad of Mirpur, Azamgarh, Babu Shashi Bhusan of Shahabad and the Superintendent of Industries in Banganapalle State were given practical instruction in Sericulture and Silk-dyeing. Amongst the visitors were also the Consul for Italy and Rai Bahadur B. C. Basu, who had been deputed specially to inquire into Sericulture in

Assam, both of whom wished to acquire special information regarding silk-work.

A multivoltine mongrel race of mulberry silkworms was established after many trials, and this at first yielded silk superior in quality and quantity to those of the Bengal multivoltine races, but this strain unfortunately began to deteriorate after the fourteenth generation and in the sixteenth generation there was practically no difference between the mongrel race and the ordinary Bengal multivoltine races. Experiments are being continued to try and obtain a stable race. The univoltine mulberry silkworm eggs which were sent for cold storage to Ramgarh (Nainital) Muktesar and Calcutta, gave satisfactory results. Mulberry silkworm eggs were supplied to 157 rearers and eri eggs to 145 rearers, and mulberry seeds and cuttings to 14 applicants. Forty pounds-weight of eri cocoons were supplied to Messrs. Killick, Nixon & Co., of Bombay, for testing in the spinning mills in England. There is still difficulty in disposing of the small lots of eri cocoons which are offered for sale by small rearers. Silk exhibits were sent to Exhibitions held at Muzaffarpur and Monghyr, materials for exhibits were supplied to Mr. Audinarainswami, of Madras, who was awarded a gold medal for his exhibit, and materials for ten sets of silk exhibits were supplied to the Deputy Director of Agriculture, Bengal. Instruction was also given by correspondence in silk-dyeing, bleaching, silkworm rearing, spinning, reeling, and weaving. A Bulletin on Mulberry Silkworms and Silk was published during the year and a Bengali translation of this is now in the press, whilst another Bulletin on "How to improve Silk-reeling in Bengal" has been written and submitted for publication. A paper on Eri Silk was read at the All-India Industrial Conference held at Karachi in December 1913 and articles on Tasar and Mulberry Silkworm rearing were contributed to the vernacular magazines "Grihastha" (Calcutta) and "Krishi Sampada" (Dacca). Approximately Rs. 400 were credited to the

Treasury during the year, being sale proceeds of silk made at Pusa.

In Madras a fieldman has been employed on special duty on Sericulture in the Kollegal District; he has given practical instruction to the mulberry-silkworm rearers and a short vernacular leaflet with practical instructions for rearing has been prepared. In Bihar, the rearing of eri silkworms at Sabour was more successful during the year under report than in the previous season; eggs were distributed to a large number of zamindars and cultivators in the Bhagalpur District, but the usual difficulty was found regarding the disposal of cocoons by the rearers on a small scale. In the Central Provinces some univoltine seed, received from Italy in October 1913, began to hatch in December and the worms, which were reared from January to April, throve well and the resultant eggs have been kept in cold storage for the next season. In the United Provinces Mr. Akhtar Mohammad Khan has been on special duty at Shahjehanpur in connection with the eri silk work and in Assam Rai Bahadur B. C. Basu has been placed on Special Sericultural duty.

Lac.—During the two Lac seasons (October and June) at Pusa, upwards of 200 *Ber* trees were inoculated and the crop scraped, washed and sold. There were no students for either course and this is doubtless due to the fact that practical instructions have been given in the Bulletin on "The Cultivation of Lac in the Plains of India," of which the first edition of 1,500 copies was soon exhausted and a second revised edition was prepared and issued during the year; a Hindi edition is now in the press and an Urdu edition is in preparation. Brood-lac was supplied to twelve applicants and answers were sent by correspondence to numerous inquirers in various parts of India. The Superintendent of Industries in Banganapalle State spent a week at Pusa picking up details of the Lac work and was subsequently supplied with seed to commence work on an experimental scale. The services of Mr. C. S. Misra were also requisitioned by the Karauli State to start and supervise

Lac-culture in that State; he obtained *Kusumb* brood-lac from Rewah, selected the localities in Karauli where work was to be commenced and started inoculation of the trees selected. After doing this Mr. Misra visited Sind to obtain *Babul* brood-lac and to study the methods of propagation practised in that district. Collection of Lac specimens by the Forest Officers continued throughout the year, the series being, however, now completed for some districts; 42 parcels were sent out and 29 parcels were received.

In the provinces little lac-work seems to be done. In the Central Provinces the inoculation done in June 1912 proved unsuccessful and this was therefore repeated in October 1913, but the insects did not thrive well.

Bees.—At Pusa the last of the imported Italian queens died in July 1913. At that time there were two colonies headed by queens reared at Pusa and in August a third queen was reared and fertilized, but in the course of the year all the three queens failed and the bees died out. The proper fertilization of the queens seems to be at present the main difficulty in establishing these bees in the Plains; the workers seem to do well and it is comparatively easy to rear new queens as required, but these are usually snapped up by insectivorous birds during their marriage-flight or, if they survive this, fertilization does not seem to have been sufficiently thorough, as after a few months they commence to produce drone-brood only. Experiments have been continued with the Indian Bee (*Apis indica*) and a mill for preparing foundation-wax for this bee has been procured, as have also queen-excluders of special size, so that these bees can now be kept in bar-frame hives under modern conditions. A Bulletin on Bee-keeping has been prepared and submitted for publication. As Apiculture in the Plains is still in an experimental stage no regular course of instruction in Bee-keeping can be given, but Entomological Students and interested Visitors have been given such information as they required.

VI.—Miscellaneous.

The correspondence work of the Entomological Section continues to be very heavy and the numerous inquiries regarding insect pests, received from all over India, are dealt with as fully as possible. During the year 1,690 letters were issued and 1,385 received, but these numbers do not include a large mass of correspondence and papers dealt with demi-officially.

VII.—Insect Survey.

The collections continue in good order and numerous additions have been made by specimens collected during tours and those sent in by correspondents. Neuroptera were received back named from Mr. N. Banks, Ichneumonidæ from Mr. Morley, and Orthoptera named by the late W. F. Kirby. The Chalcididæ have been sent to Dr. L. O. Howard, of Washington, who has kindly consented to have them determined, and the Rutelidæ to Mr. G. Arrow for his " Fauna " volume on this group. The whole of the collections will be placed in one series, in order that the whole of the information available concerning any one species may be available in one place, and this work has been commenced.

VIII.—Programme of work for 1914-15.

This will follow generally in the lines of work of the current year as outlined in the present report, and will include general investigations of crop-pests, and especially of the pests of rice, sugarcane and cotton, of fruit-trees and of stored grain. A commencement has been made of collection of information for a general book on the crop-pests of India and progress in this will be continued, as also in the publication of information regarding life-histories of pests and coloured plates, of which a large number are now ready for printing. Work and experiments in silk, lac and bee-keeping will be continued, and

new insecticides and insecticidal methods tested as occasion arises. Advice and assistance will be given as far as possible to Provincial Departments and to all inquirers on entomological subjects.

IX.—Publications.

The following publications have been actually published during the year under review :—

Entomological Memoirs.

Vol. V, No. 1. Life-histories of Butterflies, by C. C. Ghosh.

Bulletins.

No. 28. The Cultivation of Lac (Second, revised edition), by C. S. Misra.

No. 29. Eri Silk (Second edition).

No. 39. Instructions for rearing Mulberry Silkworms, by M. N. De.

Agricultural Journal of India.

October 1913. Red spider on Jute, by C. S. Misra.

January 1914. Some Experiments with Maize stored in Bins, by A. J. Grove.

REPORT OF THE IMPERIAL PATHOLOGICAL ENTOMOLOGIST.

(F. M. Howlett, B.A., F.E.S.)

I.—Administration.

I was in charge of the section for the whole of the period dealt with in this report. Mr. P. G. Patel was absent on privilege leave for one month and six days from April 14th, Mr. H. N. Sharma for two months and eight days from October 16th, and Mr. J. L. Mitter for two months from October 16th.

II.—Educational.

Messrs. C. S. Swaminath and J. L. Mitter appointed to Pusa by the Medical Research Association, finished their period of training here and have been taken over by the Medical Research authorities. Mr. Mitter has joined Major Mackie in Assam to assist in the Kala-azar investigation now in progress, while Mr. Swaminath is working with Colonel Adie in Kasauli at the transmission of *Halteridium* by flies of the genus *Lynchia.*

III.—Research.

My personal attention has been largely devoted to an attempt to work out methods of insect-control by examining and taking advantage of the reactions of insects to particular stimuli which seem to influence to a very large extent their more important activities. The lines on which one branch of this work is proceeding are indicated in an article on " The effect of oil of Citronella on two species of *Dacus* " (*Trans. Ent. Soc., London, 1912,* p. 417), and the results so far obtained encourage the hope that considerable improvements in our present methods may result from enquiry on these and similar lines, though these possibilities have hitherto been very largely neglected by entomologists.

Mr. S. K. Sen has been assisting me in the above enquiry and has also worked at the bionomics of mosquitos and particularly of mosquito-larvæ. The calomel method (see Annual Report, 1912-13) has given good results when used on a small scale in the field, and merits attention. Mr. Sen made a very careful investigation of the respiration of mosquitos in all stages, and has contributed an article on the subject to the *Indian Journal of Medical Research*. Publication of various articles by Mr. Patel and myself in the same journal has been suspended until a definite settlement of the question of " medical " work at Pusa. Mr. H. N. Sharma has also worked largely at mosquitos, and has attempted to get at the connexion between the existence of small wounds and abnormal feeding reactions. Mosquitos have been got to feed on red ink, salt solution, and other beverages, but no satisfactory explanation has been arrived at of a very curious fact.

In connexion with Major Holmes' Surra investigation, Mr. Grove, and subsequently Mr. Mitter, visited Kathgodam with the object of assisting the entomological side of the enquiry. This appears to be more complex than was originally supposed, and may necessitate the services of Mr. Patel or myself.

IV.—Veterinary.

In addition to the Surra investigation at Kathgodam and Muktesar, work on the bionomics of flies likely to be Surra carriers has continued. Mr. P. G. Patel made an extended tour in the Punjab with Colonel Newsom, and was able to give valuable assistance in the work on insect parasites. Mr. Patel has been also working with me on the habits and life-history of lice.

In the course of a tour in Madras I was able to dispel a long-standing supposition that Indian hides are seriously damaged by Warble-flies. These flies seem to be in fact rare in the plains, and an examination of damaged skins, chiefly sheep and goats, showed that the damage known in the trade as " warbles " is really due to the punctures conse-

quent on tick-bites. The rather similar damage called "pori-pori" may be due to the same cause, or possibly to lice, but it was not possible to settle this point definitely.

As Miss Ormerod states that over 40 per cent. of Indian hides are damaged by "warbles," it is as well to know that the injury is due to another cause.

Work is in progress on the egg-laying reactions of blood-sucking *Muscidæ*.

V.—Fruit-flies.

Mr. A. Mujtaba has visited Peshawar, the Central Provinces, and Bombay in the course of his work on this group, while Mr. Sen also visited Madras. The life-histories of two new species have been worked out, and a series of life-history memoirs of all the common species is now in course of preparation. The relations between the species and varieties, or local races, are evidently complex, and a complete knowledge and understanding of their bionomics can only come after a great deal of careful study. The spray method of control has proved successful and can be confidently recommended.

VI.—Miscellaneous.

In Mr. Grove's term of office as officiating Imperial Entomologist, I gave some assistance with the work on silk and silk weaving with which I was familiar, and in accordance with the recommendations and enquiries of silk merchants in Bombay and elsewhere made some modifications in our weaving practice in the direction of obtaining a more porous and absorbent cloth of a kind suitable for shirtings and the like. In this Mr. De has been successful.

I corresponded with the Chief of the Board of Health, Isthmian Canal Commission, with reference to Yellow Fever and *Stegomyia*. I forwarded to him two consignments of eggs of our common Indian *Stegomyia scutellaris* to be hatched out on arrival, in order to ascertain whether or not this species can convey Yellow Fever, a point possibly

of considerable importance to India. I have not yet heard the results of the trial.

Identifications of insects for medical officers and others has continued as usual, but presumably this work will be transferred at an early date to the official entomologist of the Medical Research Association.

VII.—Programme of work for 1914-15.

Research as indicated in para. 1, section III, above. It is hoped to complete a work on Indian Flies and blood-suckers based upon the sections written in "Indian Insect Life" on Diptera and other parasites of man and animals, but of a more detailed and somewhat less popular nature.

REPORT OF THE IMPERIAL AGRICULTURAL BACTERIOLOGIST.

(C. M. HUTCHINSON, B.A.)

I.—ADMINISTRATION AND TOURS.

I held charge of the section throughout the year excepting 14 days' privilege leave in February, when Mr. Walton was in charge.

Mr. Walton, Supernumerary Bacteriologist, has passed the vernacular examination prescribed for the Agricultural Department.

Assistants.—Mr. A. N. Bose was appointed to the vacant post of Assistant on Rs. 50—5—75 and Mr. N. P. Nandi to the fieldman's post in November 1913. On the transfer of Mr. N. C. Bose as a Bacteriological Assistant to the Sanitary Commissioner of Bengal, Mr. A. N. Bose was promoted to the post of Rs. 75—10—125 and Mr. H. D. Singh of the Chemical Section to the latter's post on 25th May 1914.

Mr. Vishwanadham, Second Assistant, was on privilege leave from 26th March 1914 to 25th April 1914. Mr. Rama Iyer, Third Assistant, was on privilege leave of one month and 29 days from 28th April 1914.

Tours.—To Dooriah to inspect manurial experiments.

To Poona, Bombay, Ahmedabad, Delhi, Calcutta and Shillong to visit various dairies in India.

To Dalsing Serai to see manurial experiments.

To Muzufferpore to see manurial experiments and to attend the meeting of the Bihar Planters' Association and to consult on use of seet.

To Sirseah to take over certain laboratory apparatus from there.

To Calcutta to consult Assistant Excise Commissioner, Bengal, Bihar and Orissa, and Assam, on Bákhar and "Pachwai," and to interview Scientific Officers of the

Indian Tea Association and Agents of various Tea Companies on the subject of green manuring, and to advise the Secretary, Ballygunge Cricket Club, on the subject of renovating turf.

To Bara-Chakia to obtain samples of Filter Press Mud and information as to amount available for use as manure.

The Supernumerary Agricultural Bacteriologist went also on tour to Bangalore in connection with examination of soils for *Azotobacter* and also to Darjeeling to attend the Cattle show and to ascertain the dairy conditions in the Darjeeling District.

II.—Training.

Mr. Barkat Ali, Assistant to the Agricultural Chemist to the Government of the Punjab, continued his course of training in Soil Bacteriology, specializing in examination of "Reh" soils from the Punjab. He will complete the two years' course in August.

Mr. D. V. Bal, Assistant to the Agricultural Chemist to the Government of the Central Provinces, is undergoing a revisionary course of chemical analysis in the Chemical Section preliminary to taking a course in Soil Bacteriology in this section.

III.—Soil Bacteriology.

The principal subject upon which work has been done in this section during the past year has been the use of green manuring, with special reference to the addition of nitrogen to the soil by this means and the availability or otherwise of this element when so added. The scheme of experiment as originally designed was intended to extend over a period of three successive seasons; *interim* annual reports were to be issued in the form of Bulletins, the final report to appear as a Memoir embodying the results and conclusions from the whole period. The first season's results were published as a bulletin and those of the second year are ready for publication in the same form; it appears doubtful whether it will be advisable to conclude the experiments with those of the current or third year as it is abun-

dantly evident that the information so far obtained forms but a small fraction of what may be derived from further study of the subject; it is also necessary to state that owing to untoward circumstances the quantitative value of the field experiments of the first two seasons was greatly diminished, which makes it necessary to repeat the more important ones. The difficulty of obtaining an area of even soil for experimental plots was well illustrated in the first year, when it was found necessary to discard the whole of one series on account of obvious initial differences between the soils of various plots; in the second year a carefully selected area taken in the middle of a large field proved its unsuitability for anything more than comparisons between adjacent plots owing to waterlogging of portions consequent on heavy rain and inadequate drainage. During the current year (1914) a fresh site has been selected which is free from such inequalities, but again difficulty has been experienced owing to irregular rainfall in June at the time of sowing and the attacks of caterpillars upon the backward plant; the latter has, however, survived, and although the six weeks old crop weighs less than two-thirds of that of the same age in previous years it is hoped that reliable comparative results will be obtained. In addition to these field experiments on the farm an area of one acre has been fenced in, cultivated, and sown with *sanai,* on the south side of the new outside laboratory, and it is hoped that experimental plots on this area laid out in triplicate divisions of $\frac{1}{24}$th acre each will help to provide controls for the field experiments carried out on a larger scale on the farm. In my previous Annual Report it was mentioned that the green manuring experiments for 1913-14 would include a trial of the use of the method of fermenting the green crop before applying it to the land, and at the same time concentrating the manurial action by restricting the treated area although using the whole of the fermented material. The result when such concentration was carried out, the fermented *sanai* being returned to about half the area on which it had been grown, in the case of the following *rabi* crop of wheat

was very apparent as a marked increase in crop, but owing to the waterlogging of part of the area and the consequent interference with the regularity of the series, definite quantitative conclusions could not be drawn as to the relative value of this method.

Small plots in the compound of the outside laboratory of about $\frac{1}{50}$th acre area were used for qualitative experiments in green manuring, the *rabi* crop being oats; variations in the method of preparing the fermented manure were tested and showed decided differences which are described in the report on the subject for 1913-14 now in hand. It was also found that for this crop on light soil no apparent advantage was obtained by concentration of the manure, improvement of the crop being probably due to the comparatively high availability of the nitrogen content of the fermented material. Further experiments dealing with the application of the method to other crops such as tobacco are in progress during the current season.

In connection with this work a considerable amount of research has been carried out in the laboratory in continuation of that of last year which dealt mainly with the ammonification and nitrification of the buried green crop; further observations on these two points have been made and in addition some fourteen species of bacteria apparently closely connected with the decomposition of buried Sann hemp have been isolated, and their physiological and morphological characters studied. It is remarkable that no one species of bacterium capable of attacking cellulose has been found so far in the general soil complex although the symbiotic relationship of two or more has been shown to produce this result; the opinion expressed in the Bulletin on green manuring published in 1914 that soil fungi probably played an important part in the breaking down of cellular tissue is strengthened by further observation; it is hoped that work on soil fungi by the Mycological Section of this institute may furnish valuable information on this point.

Part of the study of the decomposition of green manure in the soil involved investigation as to the relative rates of formation of humus and nitrate; this enquiry has not yet arrived at the conclusive stage suitable for report.

A considerable amount of work was done in connection with the changes taking place in fermenting green manure; the manurial value of this material appears to be due to the rapid formation of simple nitrogen compounds such as ammonia, from the proteid content; the nitrification of this ammonia, however, is interfered with by the fact of its concentration and also by the presence of soluble organic substances some of which at least are strongly toxic to nitrifying bacteria and in less measure to others; this condition persists so long as the water extract remains acid to litmus which under ordinary conditions of manufacture might extend to as much as six weeks, and renders it necessary to study the conditions under which such manure can safely be applied to arable or other soil. The mode of preparation may also be varied considerably with corresponding differences in manurial action; such differences are apparently correlated with the rate at which the nitrogen content becomes available and are of importance in field practice with reference to the time of application, the nature of the soil, and the nitrogen requirements of the crop intended to benefit by the use of this form of manure.

It is interesting to note that the rapid ammonification which takes place when green manure is placed in water and allowed to ferment was found to be accompanied by the development of large numbers of ciliates, flagellates and amœbœ, whose presence does not appear in this instance to be prejudicial to the activity of ammonifying bacteria; it may be conjectured that under such conditions as obtain in this case the abundance of organic food would produce a rate of reproduction amongst the bacteria which would more than counterbalance any phagocytic action on the part of the protozoa.

The conditions under which nitrification takes place in soil have naturally formed an important part of the work

of this section during this as in previous years; it was found in connection with numerous experiments made to determine the optimum moisture content for nitrification in various soils, that not only is the amount of water all-important, but that the greatest amount of nitrification obtainable depends upon treatment which takes into account the fact that ammonification is the necessary antecedent to nitrification in the case of organic matter, that this process is furthered by a high percentage of moisture, that high concentrations of ammonia inhibit nitrification, but that such ammonia is absorbed by the soil and can then be nitrified. Experiment showed that the most rapid and complete nitrification of any given quantity of nitrogenous organic matter could be effected in soil by producing anærobic conditions with water saturation and subsequently draining and aerating; the rapidity with which nitrification takes place under these conditions depends upon the relative completeness of the anærobic and subsequently of the ærobic conditions. This was the case in all the soils experimented with but may not of course be of universal application. It was found that much more rapid ammonification took place in the case of organic matter kept under anærobic conditions in soil than when free aeration was allowed, whether such anærobic conditions were produced by water saturation, or replacement of air by nitrogen or carbon dioxide or simply by tightly closing the vessel containing the soil. At the same time toxins were produced which not only inhibited nitrification before the ammonia concentration was sufficient to do so, but afforded water extracts which were toxic to seedlings and to bacteria; subsequent aeration removes this toxic condition and the formation of nitrates takes place, the ultimate result being a high percentage of nitrification of the nitrogen of the organic matter; this apparently represents the cycle of changes in the case of the fermentation of green manure described above; its application to field practice is now being studied.

In connection with the nitrification of green manure it was found that a loss of nitrate invariably occurred between

the 8th and 12th weeks of the process in the laboratory; a considerable amount of work has been done with the object of discovering whether this loss could be accounted for by correlating it with the gradual evaporation of soil water; the enquiry is not yet sufficiently complete for conclusive report, but it seems certain that the change noted is due to variation in the water content of the soil rather than to seasonal variation in the functions of the soil flora.

Experiments were made to determine the effect upon nitrification of varying the quantity of nitrogen as organic matter added to the soil; it was considered probable that any excess above the optimum would retard or even inhibit nitrification, but that the optimum might vary considerably with different soils, and also in the same soil under different conditions. An unexpectedly high optimum was found for mustard cake in Pusa soil, namely, one per cent. of the soil weight, but it was shown that the high lime content of this soil was mainly responsible for this high figure, and that in soils such as the average tea soils of Assam, with less than one per cent. of lime, a much smaller quantity of cake would fail to nitrify at the normal rate. A study was made of the progress of decomposition of cake in soils varying in lime content, by periodic estimations of the loss on ignition, humus, ammonia and nitrates; it was found that decomposition was rapid in proportion to high lime content, although in time the soil lower in lime attained the same nitrate concentration.

Isolation of nitrifying organisms from Indian soils was continued with special reference to a nitrite forming organism hitherto undescribed, the isolation of which by Mr. Joshi, 1st Assistant, is still in hand.

Azotobacter.—A number of soils was examined for *Azotobacter*, which was found in those from Naupada, Vizianagram, Waltair, Tuni, Samalkota, Ellore, Walajah Road, Bowringpet, Jalarpet, Bangalore, Darjeeling and Cawnpore.

A series of determinations of amounts of nitrogen fixed in liquid culture media inoculated with Pusa soil week by

week, and which is still in progress, shows small irregular variations. The amounts are of the same order as those obtained by Ashby at Rothamsted and by Sackett in Colorado.

Pure Cultures.—The amount of nitrogen fixed by pure cultures of *Azotobacter* isolated from Pusa soil was increased by the additions of basic slag or humus to the ordinary medium but was diminished by the substitution of magnesium carbonate for calcium carbonate. The amounts of nitrogen fixed in the pure cultures are similar to those obtained by other investigators in Europe and America.

Well marked differences were observed in the morphological and cultural characters of species of *Azotobacter* isolated from Pusa, Cawnpore, Darjeeling and Bangalore soils, and the amounts of nitrogen fixed by these also varied.

A few preliminary experiments on nitrogen fixation in the soil were carried out.

The addition of a seer of cane sugar to a plot two square yards in area, resulted in an increase, in the nitrogen content of the first six inches of soil, of nearly fifteen per cent. in 10 weeks.

The stimulation of nitrogen activity by the addition of soluble carbohydrates may possibly be of considerable practical importance in the future. It has been shown by Koch that certain bacteria can form soluble carbohydrates from cellulose which can be used by *Azotobacter* as a source of energy for nitrogen fixation; this action would bring the organic matter content of the soil into immediate relation with its possible gain of nitrogen from the air.

Some interesting results were obtained in connection with work on bacterio-toxins in soil; it was found possible to measure the relative toxicity of various bacterial species to an intermediate form (*B. prodigiosus*) and to one another, by use of plate cultures and the measurement of the rate of CO_2 formation in solid and liquid media, and the effect upon the latter of the antagonism or symbiotic action as

the case might be. Marked instances of antagonism and symbiosis were found, and the production of toxins was demonstrated; the methods in use might perhaps be employed to advantage in connection with the investigation of the physiological functions of pathogenic organisms.

Some further work on bacterio-toxins in soils was carried out in connection with the sewage-treated soil samples sent for examination by Mr. Allen of Nagpur. Work on these soils was discontinued at the request of Mr. Allen as the sewage treatment scheme on the Nagpur experimental farm is not yet in complete working order.

IV.—Special Enquiries.

Potato Rot.—The enquiry on this subject referred to in my previous report is not yet complete, but has been continued throughout the year in order to gain further and fuller information upon various points in connection with the physiological functions of the organisms involved, and the probable distribution of the latter in soil or elsewhere; this information is necessary in order to frame effective preventive measures; reports of the occurrence of tuber rot in store continue to arrive from various parts of India, and numerous samples have been examined; in many instances the rot is due to fungal and not to bacterial attack, as described by the Imperial Mycologist. A report will be issued shortly.

Bákhar.—At the request of the Assistant Commissioner of Excise for Bengal, Bihar and Orissa, and Assam I undertook to investigate the biological factors in connection with the fermentation of rice beer, with a view to determine the feasibility of controlling the manufacture of the ferment, which is at present in the hands of a peculiarly unsuitable class, generally hillmen, who make the ferment or Bákhar according to time-honoured traditional methods of more antiquity than precision. The result of the present state of affairs is a great variation in the quality of the fermented liquor, due to the presence in the Bákhar of

numerous species of ferments, and in the rice beer itself there may be deleterious substances derived from the same source. It is thought that the manufacture of the Bákhar or yeast might with advantage be controlled in order to provide brewers with a reliable ferment of uniform composition and action, and examination of samples of this material from various sources shows that the fermenting organisms present differ widely in character and effect.

The fermentation of rice differs from that of barley in one important respect, in that the rice as a consequence of husking loses its power of germination, and with it is also lost the natural change from starch to sugar produced by the enzymes formed during this process; this change in the case of barley is characteristic of the operation known as malting, which results in the change of the starch of the grain into sugar, a necessary antecedent to fermentation by yeast. In the case of rice it is therefore necessary to produce the change of starch into sugar known as saccharification, by the addition of some form of saccharifying ferment which will provide the enzyme diastase by which this change may be brought about. Barley grain on germination produces diastase which under suitable conditions converts the starch of the grain into sugar, the grain thus altered in composition being known as malt; the same result is obtained with rice by the addition of Bákhar which contains various fungi or moulds whose natural growth on a starchy medium is accompanied by the secretion of diastase. The efficiency of a sample of Bákhar (which is made up and sold in the form of small greyish white cakes of about one ounce in weight) will therefore depend firstly upon its containing an efficient diastase-producing fungus, and examination has shown that the samples collected from various sources differ widely in respect to the kinds of fungi present and their correlated diastasic power with regard to rice starch. When the Bákhar cake is powdered and mixed with rice which has been prepared by moistening, the fungi present form mycelial growth which involves the rice grains and gradually converts their starch into

sugar, the completeness of this result depending upon the suitability of the conditions provided and upon the presence of fungi of adequate diastasic power. A large number of different species of fungi were found in various samples of Bákhar and the rapidity and completeness of the saccharification of the rice starch also varied in accordance with their relative diastasic powers, which were measured in pure cultures. It may be said that no one of the numerous species found compared favourably in this respect with *Aspergillus Oryzæ* which is the organism used for this purpose in Japan in the manufacture of "Sake" or rice beer, by the use of the corresponding preparation to Bákhar known in Japan as "Koji;" it is possible that the introduction of *Aspergillus Oryzæ* into India might considerably improve the rice beer of this country.

When by the action of the diastase-producing fungi a large proportion of the starch of the rice grain has been converted into sugar, mostly maltose, the next step is the fermentation of the sugar by yeast with formation of alcohol. In the very full and interesting account of the use of Bákhar by J. C. Ray published in the *Journal of the Asiatic Society of Bengal* (Vol. II, No. 4 of 1906) the author ascribes this alcoholic fermentation to the mucors which have already exerted a saccharifying influence on the starch; I have never failed, however, to find yeasts present in Bákhar capable themselves of producing alcohol without involving the supposition put forward that mucors in their vegetative condition secrete diastase but in the reproductive stage produce zymase, the alcohol producing ferment. The yeasts found varied just as the mucors and other fungi were found to do, and as it is a well known principle in brewing and distilling that the variations in physiological characters of the yeasts involved require careful selection of the latter and exclusion of undesirable varieties, it is very probable that the haphazard introduction of unknown numbers of kinds of yeast into rice beer by the agency of Bákhar would afford another point over which control might usefully be exercised.

A third point arises in connection with the use of Bákhar; as will readily be understood, when any organic matter such as moist rice is exposed to the air the ensuing fermentation is likely to be complicated by the presence and activity of bacteria; in the case of beer brewed in Europe from barley-malt and hops, the value of the latter depends upon their content of lupulin with its associated "hop resins" which act as preventives of bacterial action; Bákhar contains many substances the inclusion of which probably originated in an attempt to prevent putrefactive changes, although now they form merely parts of the tradition or trade secret handed down without knowledge of their specific function, or of the fact that whilst the mouldiness aimed at is produced by fungi, the putrefaction sometimes resulting is due to bacteria.

Chillies, ginger, and the bark and roots of various plants are among the substances incorporated with the ground rice to form Bákhar cakes; so far the function of the various substances examined appears to be to restrict the growth of bacteria during the earliest stages of infection of the rice to be fermented until the growth of the mucors has become strong enough to suppress bacterial competition, and in this respect they resemble the hop resins in action.

Many of the substances added to Bákhar by the makers are no doubt intended to produce other effects which would, however, be confined for the most part to the beer and would not, appear in the distilled spirit; it has been reported that *Datura* and *Nux Vomica* are sometimes used in this way and it is natural to suppose that the reputation of a Bákhar maker might be enhanced amongst a certain class of his clients by such reprehensible practices. Specimens of a plant said to be a necessary ingredient of Bákhar as made in the Darjeeling district, have been sent to me for examination; this plant is known to the Limboo tribes as "Wadinghangma" and to the Nepalese as "Bhimsen pati;" it has been identified by the curator of the Lloyd Botanic Garden in Darjeeling as

Polygala arillata; the bark of the roots afforded a decoction, the antiseptic properties of which are now under examination.

Biological Analysis of Soils.—

Reh Soils.—Samples of " Reh " soil received from the Agricultural Chemist to the Government of the Punjab were under biological examination and formed a subject of study for Mr. Barkat Ali, a student from the Punjab who is undergoing training in soil bacteriology in this section. Several interesting facts were discovered as to the effect of lixiviation upon the flora of these soils, and the conclusion was arrived at that the normal processes of ammonification, nitrification and nitrogen fixation would be the natural consequence of removal of the excess of salts from the soil by this means; Mr. Barkat Ali has furnished an excellent report upon his work which encourages the belief that a well trained chemist can acquire sufficient knowledge of the methods of biological analysis as practised in this laboratory to enable him to carry out such work satisfactorily without excessive supervision after a two years' course of instruction.

Biological analyses of soils from Cawnpore, Sind, Assam and Nepal were carried out and reports upon them furnished; the method used is still under revision owing to the necessity for variation in accordance with the character of the soil and the information desired.

V.—Programme of work for 1914-15.

Major Subjects.

(1) Nitrification.
(2) Nitrogen fixation.
(3) Biological Analysis of soils.
(4) Investigation of effects of management upon the constitution of the Soil Complex.
(5) Green Manure experiments.

Minor Enquiries.

Potato Rot and other Plant Pathogens.
Bacterio toxins in Soils.

VI.—Publications.

Acting in conjunction with the Imperial Agriculturist I made a series of tours as detailed above with the purpose of investigating the conditions under which dairying is being carried on in India at the present time, and furnished a report dealing with this subject. (Published as appendix F to the Proceedings of the Board of Agriculture in India held at Coimbatore on the 8th December 1913 and the following days.)

A Bulletin on Green manuring (Pusa Bulletin No. 40) recording the experimental results of the first season's work on this subject was published.

REPORT OF THE IMPERIAL COTTON SPECIALIST.

(G. A. GAMMIE, F.L.S.)

I.—CHARGE AND TOURS.

I held charge of the appointment throughout the year.

Tours.—In July, I visited Simla to assist the Officiating Agricultural Adviser to the Government of India in drawing up a note on the present position of cotton in India; in October I visited the Punjab to advise the Director of Agriculture in consultation with some members of his staff, as regards the present and future lines of work to be undertaken in cotton; in the same month I also visited the United Provinces, where I met Dr. Parr and Mr. Wilson, the Officiating Economic Botanist. In November I visited Sind, in the company of the Director of Agriculture, Bombay, to discuss certain details in cotton cultivation in Sind; in March 1914 I visited the agricultural stations in Guzerat, including Baroda, and the Southern Mahratta Country. The remainder of the time during the year was devoted to the supervision of my own experimental area, to the giving of advice to many correspondents and to arrangements connected with the valuation of numerous samples forwarded for my opinion.

My assistant, Mr. D. P. Mankad, made several tours in Guzerat, Kathiawar, and the Southern Mahratta Country throughout the year.

II.—COTTON IN THE PROVINCES.

Punjab.—After my visits of inspection I furnished the following short note to the Director :—

" There are three distinct types of American cottons, (*a*) Upland Georgian, (*b*) New Orleans and (*c*) annual form of soft Peruvian. The first, on account of its hardiness and immunity from the attacks of pests, is obviously the

type which should be introduced into general cultivation; the second is less hardy in its nature. It is attacked by Jassids this year and its superiority to Upland is so trifling that it is not worth the risk of being maintained. The soft Peruvian is one of the finest cottons ever grown in India. Its low outturn (in spite of its higher price), however, brings it on a par with Upland. This variety should not be distributed indiscriminately, but should be brought to the notice of farmers of good position who would undertake to give it the necessary care and attention. I would advise that your selections of American cottons be kept down in number. Many at present existing do not differ sufficiently from one another to deserve being kept separate.

" As regards the *Deshi* cottons, a survey should be carried out in each tract so that the dominant forms in each can be extracted and tested comparatively as pure types. Those passing the test could be rapidly multiplied on seed farms for distribution to cultivators. It is almost unnecessary to point out that aid should be given in the marketing of the produce until the trade is disposed to pay fair prices spontaneously.

" Mr. Milne's discovery that root-rot is caused by a nematode worm is most interesting and I hope he will publish his notes as soon as possible. He has now on his Botanical area pure strains of all the varieties of cotton found in the Punjab. These can be compared with your survey types and time could be saved by making a start from these for your seed farms."

Since writing the above I have heard that the cottons of the districts of Lyallpur, Hissar and Lahore have been surveyed with the following results :—

Lyallpur Tahsil.—*Gossypium indicum*, yellow flowered, is the prominent form.

Toba Tek Singh.—*Gossypium sanguineum*, both broad-lobed and narrow-lobed, chiefly near Gojra, and *Gossypium indicum*, yellow flowered, in almost as great quantity.

Sumundri and Jaranwala.—*Gossypium indicum*, yellow flowered, and *Gossypium neglectum*, yellow flowered, in almost equal quantities.

There is everywhere a fairly considerable admixture of the white flowered varieties of *Gossypium indicum* and *neglectum*, and these, popular opinion regards as heavier yielding. Certainly the percentage of lint is higher in the white flowered varieties grown in the Lyallpur Station. *Gossypium sanguineum* is not uncommon in the Lyallpur and Sumundri Tahsils, but it is the predominant type in few villages.

Hissar.—In Hissar, Hansi and Fatehabad Tahsils two-fifths are yellow flowered *Gossypium indicum* and one-fourth to one-third is white flowered *neglectum*. There is no *Gossypium sanguineum*. Cotton is unimportant in Bhiwani and Sirsa Tahsils.

Lahore.—Yellow flowered *Indicum* represents 74 per cent. in Chuman, 78 per cent. in Kasur and 91 per cent. in Lahore Tahsil. In Chuman about 10 per cent. is yellow flowered *Gossypium neglectum*, in Kasur there is a good deal of broad leaved *Gossypium sanguineum* in canal-irrigated villages.

As regards the retention or rejection of American varieties, those retained are of the rough leaved and those thrown out are of the smooth leaved type. 4 F is the chief American cotton on the Station and it has done well everywhere in 1913. The experience of past years shows that American cottons will do well in the colonies under canal irrigation, but they require good land and better cultivation than the indigenous cotton.

United Provinces of Agra and Oudh.—In connection with my tour in these provinces I supplied the following short note :—

" The lines of work in Dr. Parr's division are :—

(1) The substitution of the prevailing mixture by the

distribution of the seed of a productive white flowered indigenous cotton. The colour of the flower is of important assistance in maintaining the purity of the type. There are now 20,000 acres of this under cultivation and it may cover the whole cotton area of the division in the course of a very few years. The whole of the seed cotton is ginned under the personal supervision of Dr. Parr, so that the chance of mixture is avoided.

The introduction of this variety teaches the cultivator the value of a pure crop and after he has learned his first lesson a second could be commenced by issuing one of the higher class yellow flowered types, of which one at least shows great promise here.

(2) Regarding the comparative merits of Cawnpore-American and *Bhuri*, Dr. Parr considers that the latter will be more profitable and I am disposed to agree with him. Mr. Burt is, however, of a contrary opinion and the difference can only be settled by making comparative tests.

Previous experience with the Cawnpore-American certainly pointed to the fact that the outturn of American cotton in the United Provinces tends to diminish more and more every year.

(3) Cambodia, on account of its prolonged season of growth, is not at all promising and its cultivation should be given up.

(4) The problems to be solved in the United Provinces are simple, one being the introduction of a longer stapled sort (either American Upland or an Indian hybrid as Mr. Leake is attempting), the other being the substitution of a good-paying pure *Deshi* crop in the place of the mixture, which is now universally grown."

In acknowledging the valuations of samples of cotton which were sent to him, Mr. Burt gave me the following interesting information:—

"The results of spinning trials at the Elgin Mills and of a valuation by the British Cotton Growing Association show that the Cawnpore-American is valued more highly than the Dharwar American. This difference is, however, not important as the Dharwar variety does not do so well here as regards yield and is much inferior to the Cawnpore variety in ginning percentage. From the valuation based on larger samples I am inclined to think that the Cawnpore-American is more nearly equal to Middling American than Messrs. Tata and Sons' valuation.

"As regards Boyd and Black Rattler, I am rather surprised to find that Boyd is valued so much above Cawnpore-American, as there was little difference as far as we could tell here. Boyd is, however, one of the most promising of the imported varieties and ginned well. As regards the Black Rattler, it is impossible to say as yet whether this will yield sufficiently well to be worth growing here. It is a later plant than the Cawnpore-American, but has not yet been fully acclimatized. In the meantime we are continuing trials of these and other cottons and at the same time trying to select uniform agricultural types from them. The Cawnpore-American variety yielded well last year on a considerable scale and we have about 500 to 600 acres of this variety this year, having received a guarantee of a minimum price of $6\frac{1}{2}$ per lb. for the lint *plus* premium depending on the spot price of middling American."

During the cropping season I deputed Mr. Mankad to Kathiawar to assist the Assistant of the Economic Botanist, United Provinces, to select types of Kathiawar cottons for experimental purposes at Cawnpore.

Central Provinces.—From valuations made on a set of samples, with details of acreage, outturn and percentage of cotton to seed, supplied by the Akola Experiment Station the varieties grown in Berar fell into the following order

of merit placed by the market value of the clean cotton alone :—

	Rs.	
(1) Gossypium neglectum, *var.* Rosea .	60	per acre.
(2) Gossypium neglectum, *var.* Cutchica .	58·5	,,
(3) Gossypium hirsutum, *var.* Bhuri .	53·75	,,
(4) Gossypium neglectum, *var.* Vera .	51·5	,,
(5) Gossypium neglectum, *var.* Vera (Berar Jari)	45·5	,,
(6) Gossypium indicum (Bani) . .	41·4	,,
(7) Gossypium neglectum, *var.* Saugor Jari	41·12	,,
(8) Gossypium neglectum, *var.* Malvensis	40·5	,,

This proves that the cultivators are abundantly justified in their selection of white flowered cottons (of which the two chief head the list), for profit, *Bhuri* follows closely in value and the remaining yellow flowered indigenous cottons fall appreciably in the rear. *Saugor Jari* has solid qualities for its own tract but it cannot compete with the natural denizens of the real cotton soil.

Madras.—A parcel of Cambodia cotton grown at the Hagari Station was the only material submitted to me for opinion during the year. The outturn of *kapas* was 631 lbs. per acre and the ginning percentage was 37·5. In the Bombay market the cotton was valued at Rs. 295, Madras Cambodia of the day standing at Rs. 315. The value of the cotton alone was therefore Rs. 89 per acre, a very satisfactory result.

Bombay.—Sholapur District.—Seed of Gossypium neglectum, *var.* rosea, was supplied to the Inspector of Agriculture, Sholapur, at the request of the Deputy Director of Agriculture, Southern Division. It was tried at Barsi, where the crop suffered much from want of rain, and at Sholapur, where the crop was very vigorous, perhaps owing to the fact that it was irrigated four times. At Barsi the outturn of seed cotton per acre was 364 lbs. and at Sholapur 1,510 lbs.

Manjri Station.—At this station experiments, with the view of introducing some paying sort of cotton into the

sugarcane tracts are still persevered with and I made an inspection and reported as follows :—

" I do not consider that there is any hope of success in any of the *neglectum* varieties under irrigation. Broach has already been tried and the results were very unsatisfactory.

" *Cambodia* seems to be the only good cotton so far that thrives under irrigation and it seems to do well round Poona where conditions are favourable. At Manjri, you have tested it under irrigation for the first time. It has received four waterings which are quite sufficient. As regards spacing, we agree that the best distance is 3 feet between rows and one foot apart in the lines. As to time of sowing, I would advise it to be done as soon as the soil is moist enough after the first rains."

The total yield per acre was 347 lbs. of seed cotton and the percentage of cotton to seed 40·3. Messrs. Tata, Sons & Co. reported as follows on a sample sent to them for opinion :—" It has lost in length of staple and is also weak. It shows deterioration. The value is Rs. 265 per candy against Rs. 310 for Madras Cambodia."

The value of the cotton produced is only Rs. 47 per acre. The result is discouraging, but I have advised a repetition of the trial.

Agricultural College Farm, Poona.—Although this is not within the cotton tracts, a number of experiments on cotton were conducted under very favourable conditions.

Fourteen small plots of *rosea* were treated with varying mixtures of farm-yard and artificial manures : the control plots being unmanured or treated with farm-yard manure alone.

Messrs. Tata, Sons & Co. reported as follows on the 14 samples submitted to them :—

" These are almost all alike with the exception of Nos. 1, 7 and 11, which are a little better than the others. Compared with type 23 (Khandesh from Dhulia), they show no improvement, they are a little inferior in length of staple and all

have rough feel. Value of 1, 7 and 11 Rs. 202 each, the rest, Rs. 200 (Fully Good Khandesh standing at Rs. 205)."

This experiment must be continued for a few years before any definite observations can be deduced.

Bhuri was reported on as having long staple but weak fibre.

The fibre of *Cambodia* was found to be very weak.

Of three sets of *rosea*, the first with the seed separated by gravity produced a crop which was found to be better in staple and soft in feel and was valued at Rs. 215; of the second, with seed not separated, the cotton was a little inferior and was valued at Rs. 210. The third from Akola seed was rough in feel and short in staple and was valued at Rs. 205. In this instance, there was a decided advantage gained by separation of the seed before sowing.

The white flowered narrow lobed variety from selections was valued at Rs. 202 equal to that of Nos. 1 to 14, which are of the same type.

Broad lobed variety from selections of *Malvensis* was valued at Rs. 237 against Rs. 235 from seed from Akola.

In Khandesh variety of which fresh seed was received from Dhulia and grown here, the cotton was deteriorated, the staple was very short and resembled Bengal cotton more than Khandesh. Value Rs. 205 (Fine Khandesh standing at Rs. 215).

Karkheli had deteriorated somewhat, valued at Rs. 265 against Fully Good Karkheli at Rs. 275. White flowered, broad lobed (*Cutchica*), farm seed, resembles Fine Bengal, valued at the same rate, *viz.*, Rs. 205.

Of the four plant-to-plant selections of yellow flowered broad lobed, *neglectum* type, No. 2 comes first at Rs. 242, No. 4, second, at Rs. 240, No. 3, third, at Rs. 238, and No. 1, fourth, at Rs. 235 (Fine Khandesh of the same date at Rs. 215).

Of the two yellow flowered narrow lobed *neglectum* plant-to-plant selections, one is valued at Rs. 235, the other at Rs. 237.

Of four white flowered broad lobed *neglectum* and three white flowered narrow lobed *neglectum* plant-to-plant selections, one only was valued at Rs. 215 equal to Fine Khandesh; the rest at Rs. 212, equal to Bengal cotton, Rajputana style.

An analysis of the outturns per acre of eight varieties shows that they stand in the following order of their value :—

Serial No.	Name of variety.	Value of outturn per acre of cotton.
		Rs
1	White flowered broad lobed *Neglectum* (*Cutchica*)	112·5
2	Khandesh Local	107·1
3	Rosea (*Varhadi*)	95·16
4	Buri	93·66
5	Yellow flowered narrow lobed (*Vera*)	78·87
6	Yellow flowered broad lobed (*Malvensis*)	59·81
7	Karkheli (*Indicum*)	53·68
8	Cambodia	34·89

The white flowered varieties of cottons, as usual, have been proved to be the most profitable. It has also been proved in the Deccan that the duration of these plants is far longer than either in Berar or Khandesh and that the production of cotton also persists over a longer period.

Guzerat.—I supplied the following notes after the inspection of the cottons on the experimental stations in the province :—

" Surat.—I consider that Selection IA and Selection II are the varieties that should be persevered with, because, of both, the outturn and ginning percentage are above the figures of the local cottons and even above those of the improved crosses already distributed. If the samples of these varieties are submitted to me for valuation, I shall have them thoroughly examined.

" Mr. Bhimbhai informs me that, last year, of No. 1018-P. G., selected Broach, 10,000 acres were sown in British territory and 7,000 acres in Baroda. The Syndicate secured 5,000 bales out of the total of 7,000, the remainder was sold independently by the cultivators to other merchants when the Syndicate ceased buying. This year, 7,000 acres have been put out and one merchant, Mr. Motibhai Raghawji of Surat, is offering Rs. 5 for 960 lbs. of seed cotton over market rate. The Agent of Messrs. Whittle & Co. at Bardoli is also satisfied with the result and they are paying Rs. 4 above the market rate. There is a strong probability that these selected varieties will be maintained by the cultivators, in spite of the withdrawal of the Syndicate's offer.

" Mr. Bhimbhai considers that it will be quite practicable in villages which grow blocks of these selected cottons to form Committees to settle the disposal of the produce without the intervention of middlemen. The new varieties are maintaining the improvement in the ginning percentage.

" Selection IA, out of selected Broach, gives 35·5 or nearly 3 per cent. over the local variety. In the quantity and quality selections No. 2 out of selected Broach, the quality is good and the ginning percentage is 34. This year, it is expected to also stand highest in yield.

" *Cambodia* is abandoned as being unsuitable for the black soil.

" Nadiad.—Cambodia cotton is being attacked by wilt and also by aphides this season. The percentage has fallen to 31. In appearance its lint is much the same as that of *Lalio*, which, being indigenous to the tract, is not so liable to be influenced by abnormal seasons. In the district there is a difficulty in the marketing of the produce, but as many of the cultivators are making their own arrangements for the importation of the seed, the final disposal of the crop should remain in their own hands.

" The cotton crosses on the farm show so very little promise that it would be well perhaps if the officers concerned

drop them and concentrate their attention on the improvement of *Cambodia* and *Lalio*. The increase in the percentage of cotton to seed is the point to be aimed at in the former and the high yielding capacity in the latter is desirable. In my own opinion, *Lalio* will prove to be the cotton most suitable for the tract. During next season *Bhuri*, *Cambodia* and *Lalio* are again to be tested.

"The Superintendent of the Nadiad Farm says that *Cambodia* has been grown on a fairly large scale by cultivators, who now find a difficulty in the disposal of the produce, of which the total amount is still so small that the ginning factories do not care to make any special arrangement for it. If the cultivation extends, assistance ought to be furnished to them from the Department. The cultivators find that the crop is inclined to mature late and they still maintain an open mind regarding the comparative merits of *Cambodia* and *Lalio*."

The following valuations of samples of Guzerat cottons were kindly supplied by Messrs. Tata, Sons & Co. :—

Surat Farm.

Serial No.	Name of sample.	Remarks.
1	Selection IA selected .	Compared with No. 7 (Surti-Broach), No. 1 (Surat selected) is decidedly longer and stronger in fibre and besides the fibre is even. It can be compared with best Surat except in softness, the feel being rather coarse. Value Rs. 320.
2	Selection IA General .	Fibres rather uneven. Length also shorter than No. 1. Value Rs. 310.
3	1018 P G General .	In all respects same as No. 1. In feel it is little softer, rather uneven in fibre, but may be a little bit longer. Value Rs. 320.
4	1027 ALF II selected .	This is very long stapled strong fibred cotton and deserves to be encouraged. It is almost equal to Navasari cotton both in length and strength, and though acclimatized for a number of years, it has in no way deteriorated. Value Rs. 335.
5	Do. General .	Almost same as No. 4, but variable in length of fibre. Value Rs. 320.

Surat Farm—contd.

Serial No.	Name of sample.	Remarks.
6	Selection II selected	Compared with No. 1, there seems to be not much difference except that No. 1 is more regular in fibre. Value Rs. 315.
7	Surti Broach	It cannot stand comparison to any of the above 6 samples, being shorter in staple and weak in fibre. Value Rs. 300.
	Sisodra Plot.	
1	Selection I selected	Of the three samples, 1, 2 and 3, No. 1 is the best, No. 2 comes second and No. 3 comes last. Value them respectively at Rs. 320, Rs. 315 and Rs. 310.
2	1027 ALF II General	
3	Navasari Local	
	Nadiad Farm.	
1	Lalio	This cotton shows deterioration on Nadiad Farm. Value Rs. 260.
2	Cambodia	This also has deteriorated considerably. Value Rs. 275.
3	Bhuri	This also shows deterioration and is very irregular. Value Rs. 255.
	Dhulia Farm.	
1	Surat-like	It shows a great deal of improvement, the cotton being almost equal to Surat in length and strength of fibre, though not in feel and silkiness. Value Rs. 305.
2	Broach-like	This shows no improvement. It is very irregular. Value Rs. 275.
3	N. R. Cotton	This cotton has more the characteristic of Assam cotton and woolly in feel. The staple is short. Value Rs. 220.

Basis of prices on 27th June 1914 :—

	Rs.
Broach	290
Madras Cambodia	330
Surat	315
Fine Bengal	215
Navasari	335
F. Dhollera	270

Kathiawar.—The following note was drawn up by Mr. Mankad, Assistant to Cotton Specialist, for the information of the Morvi State, which called upon us for special advice :—

" The District resembles South America in shape; the average rainfall is 18 to 22 inches, very irregular in distribution which tells considerably upon the production of the cotton crop.

Soils.—There are three kinds of soils, *viz.*, (1) black cotton soil, (2) besar and (3) light. The last named is chiefly met with in the southernmost part of the State towards Tankara.

Rotation.—Cotton is rotated mostly with Jowari in cotton soils, but in lighter kinds of soils Bajri forms the principal rotation.

The average area devoted to the culture of cotton in the State varies from 1,25,000 to 1,40,000 acres per annum. Broadly speaking, on account of enhanced prices of cotton, of late, two-thirds of the total cropped area is annually put out under it, as it pays better to the grower. The average outturn may be computed at 100 lbs. clean cotton per acre. In recent years, however, it has become the general practice to grow cotton without any rotation whatsoever, on the same land, and it is held amongst the cultivators that there is no diminution in the outturn. Economically the practice has proved a sound one owing to the high price of cotton.

Varieties of cotton.—Practically speaking, there are only two varieties in the State, called (1) *Deshi* or *Wagad* (bolls of which are picked out bodily from the plant and the cotton extracted at home), and (2) *Kanvi*, acclimatized Broach, the seeds from Kahnum of the Broach District seem to have been brought in these parts some 25 years ago; in addition to these two, there is a third variety called *Mathio*, mixture of all the *neglectum* types that compose the cottons of Khandesh and Central Provinces, which occupies a very small area in the south of the district towards Tankara

and is grown in light soils only, to get the crop ready before frost occurs as this tract is more subject to it.

The actual area under each of these three varieties is not separately kept, but it is understood that *Deshi* or *Wagad* occupies the largest area. Of the two principal varieties, *Wagad* is raised purely as a dry crop, but *Kanvi*, wherever there are facilities for irrigation, is given two or three waterings; as an irrigated crop, it gives a larger return. *Kanvi* matures also three weeks earlier than *Wagad*, the picking of *Kanvi* cotton is easier than that of *Wagad*, as it bursts out from the capsules when the bolls ripen; in the case of *Wagad* cotton, however, the opening of the bolls is not perfect, so that the bolls are plucked off and cotton extracted at home, which entails extra expenditure.

Forty pounds of *Wagad* bolls give 28 lbs. of *kapas* after extraction. The charges for taking out cotton from the unopened bolls vary from one anna to three annas according to seasons. This work is mostly done by women.

There are three distinct cotton tracts in the State according to the quality of cotton produced.

(1) The eastern portion is known as the Nadipar, which is practically free from frost, the cotton produced in this tract is offered 4 annas more per maund than that produced in the Boidiar tract.

(2) The western portion is called the Boidiar tract (there are many *bor* trees, *Ziziphus jujuba*). This is partially subject to frost. The produce of this tract is considered inferior to that of Nadipar but better than that of the Tankara tract. In this tract *Wagad* cotton is pollarded. Cultivators believe that the yield and quality of the rattooned crops are maintained. This belief is incorrect. The rattoon crop was valued at Rs. 245 per candy against Rs. 255 of the fresh crop of *Wagad*, the rattoon crop is also bound to fall off in ginning percentage in addition to the quality of cotton. I am informed

that a large area is kept under the rattoon in this tract in order that the crop may be picked out before the frost occurs.

(3) The southern portion is known as the Tankara tract which generally suffers from the effects of frost. *Mathio* is, therefore, grown in lighter kinds of soils to get an early crop. As *Mathio* produces a very small crop, the produce is usually mixed up with two principal varieties already mentioned. The quality of cotton of this tract is considered inferior to that produced in the eastern and western portions.

With regard to the quality of cotton, I feel that both *Wagad* and *Kanvi* are equally good. The crops vary slightly according to seasons only.

Kanvi.—The staple is slightly longer, fibres weak, cotton dull in colour and thin.

Wagad.—The staple is slightly shorter, but strong and white in colour, in addition, the cotton is *bulky.*

Bulk for bulk *Wagad* cotton fetches on an average Rs. 10 more per candy than *Kanvi.*

Samples of both these varieties were obtained from each of the three tracts and were submitted to Messrs. Tata, Sons & Co. for opinion. The following are the valuations of each of these samples.

Basis of valuation on 6th May 1914 :—

	Rs.	
Fine Broach	265	per candy of 784 lbs.
Morvi	250	,, ,,
Nadipar tract.		
Wagad from Jetpur . . .	240	
Kanvi	235	
Boidiar tract.		
Wagad	255	
Kanvi	250	
Aroora (rattoon) . . .	245	

Tankara tract.

	Rs.
Wagad	250
Kanvi	240

From the valuation report it will be seen that the quality of cotton of the Boidiar tract is superior, then comes the Tankara tract and lastly the Nadipar, which ought to come first. This is puzzling, but it may be capable of explanation. My own observations in these three tracts lead me to believe that in the Nadipar tract, cotton matures a little earlier than in the other two tracts and being adjacent to the Dhrangadhra State, should produce cotton of better quality. The same two varieties are being grown in the Dhrangadhra State and fetch Rs. 10 more per candy than the Morvi cottons in the Bombay market.

Selection of seed.—It is gratifying to note that the *kunbis* who form a majority of the agricultural class are exceptionally keen on selecting well-opened bolls and hand-gin the same for seed requirement. Seed for sowing purposes is never brought in either from the ginneries or from Banias' shops by the *kunbi* cultivators.

Seed for sowing is also carefully stored in earthen *chattis.*

Hand-gin.—This differs from that used in other parts of India (excluding Kathiawar). It is an ordinary gin to which a fly-wheel is attached, the price of such a gin depends on the quality of the fly-wheel, but it may be taken at Rs. 10 to Rs. 15. The work done by this hand-gin with the *herbaceum* types of cotton is 160 lbs. of *kapas* per day, working at the rate of 12 hours a day requiring two men and one woman.

In addition to ginning cotton for seed requirements, the *kunbi* cultivators take out sufficient seed for cattle for the year by means of such gins; a portion of the lint obtained is spun by hand for making clothes, ropes, etc., to meet domestic and agricultural requirements and the surplus is sold. The hand-ginned cotton fetches Rs. 10

less than the machine-ginned per candy, as the former contains comparatively a larger percentage of broken leaf, dirt, etc.

With regard to general cultivation, it should be mentioned that the *kunbi* cultivators are first class people in handling the land. The cotton fields were found scrupulously clean throughout and the agricultural operations perfect. The standard of cultivation could, however, be raised by deep-ploughing, etc.

As the rainfall is very precarious, it is suggested that a bullock-hoe of the Surat type (curved blade) for interculturing might prove more beneficial than the local hoe in the conservation of soil moisture. I have personally explained its advantages to the Revenue Commissioner and the Patel of Mandan. A blade of the Surat hoe has already been sent from Surat.

Varieties actually under trial.—In the Kesawala garden, trials were made in sample plots with five varieties including two perennial cottons, *viz.*:—

(1) *Kumpta* (seed obtained from Miraj).

(2) *Dharwar American* and *Cambodia* (Upland types).

(3) Seed received from Rangoon (*Neglectum* types).

(4) And with varieties of perennial cottons, *viz.*:—

Spence and *Kidney* or chain-seeded.

All these had received waterings.

(1) *Kumpta.*—The growth was satisfactory, the crop had not ripened but a few bolls that had opened were examined; cotton was thin on seed, as is usually the case with this variety, though the quality of cotton was almost equal to *Kumpta* of the Southern Mahratta Country. The local cotton (*Wagad* or *Deshi*) is superior in all respects to *Kumpta*, as the percentage of cotton to seed is greater than the one under trial, and the cotton is also bulky.

(2) *Dharwar American* and *Cambodia.*—The former had practically failed, on account of the attack of leaf blight, the latter grew satisfactorily, branching in all directions. On examination the fibre was found weak and the staple comparatively short, though it showed high percentage of cotton to seed. This quality may fetch Rs. 20 to Rs. 25 more per candy over the local cotton.

These varieties were planted out too far apart (6 feet on either side). The American annual forms are grown in the same way as the local cottons, *i.e.*, lines 2 feet apart and distance from plant to plant 1 to $1\frac{1}{2}$ foot in the row.

(3) *Seed from Rangoon.*—The resulting plants were of the *neglectum* type, the ripening period had considerably prolonged, probably due to irrigation. In parts where the *neglectum* types are grown, the crop requires five to six months only to mature. The quality of cotton is in no way superior to the local cotton; it should, therefore, be abandoned. This is something like *Mathio* cotton.

(4) and (5) *Spence and Kidney cottons (perennial varieties).*—These had made very unsatisfactory progress. Results of a few years' experiments proved plainly that all the varieties of tree cottons possessed so many inherent defects that their profitable cultivation was impossible *on a field scale.*

Mr. Spence's attempts at the cultivation of *Spence* variety on a large scale at Deesa and Jamnagar, Mr. Tytler's at Belgaum with *Rough Peruvian* and Messrs. Shaw, Wallace & Co.'s in Bengal with *Caravonica* and almost all tree cotton varieties hopelessly failed and no one reports even moderate success with them.

The chief drawbacks in their cultivation are :—

(1) Their very structure is that of woods and sheltered places.

(2) Their brittle nature forbids their being grown in open fields exposed to winds.

(3) They are more subject than the annuals to insect pests and these are carried from year to year and the land becomes weed-infected.

(4) And finally, the steadily decreasing annual outturn is the strongest argument against their cultivation.

In conclusion, it can safely be said that the tree cotton which will succeed in India as a *field crop* has still to be discovered and it is extremely risky to attempt the hopeless task of tree cotton cultivation on a commercial scale.

In the new garden, I was shown about half a dozen grafts that had been made between the *Arboreum* and *Deshi* cotton according to the new discovery by a German named Schætin. It has been suggested to collect all the cotton when the bolls ripen and to put out a larger area next season to test the results. In our opinion, it is highly probable that the cotton plant with its brittle wood and tough fibrous inner bark does not allow of any process of grafting, which will produce frost-resistant types possessing desirable quality of cotton.

I was taken over the proposed area of 2,000 acres in 3 blocks in the Tankara tract, which is to be left at the disposal of an American expert, whose services have been lately acquired, to test the suitability of various crops. Most of the land is under cultivation, flat, with facilities for irrigation, in fact, beautiful to work with and it is hoped that the authorities will spare no pains to tackle various points connected with the improvement of cotton.

I had also an interview with His Highness the Thakore Saheb of Morvi, who takes keen interest in the improvement of the cotton crop, and we discussed the cotton question at full length. He desired to try *Broach* seed, which has been supplied. As the rainfall is scanty, I am afraid that the long duration of growth required by *Broach* cotton might tell upon the opening of the bolls.

In conclusion, I think that the two local varieties *Wagad* and *Kanvi* are in every respect suitable to these parts and the products meet the demand quite satisfactorily. As the conditions of soil and climate do not seem to favour any other variety, either Indian or foreign, I would suggest that attention should be directed to increase the outturn by better methods of cultivation and improve the ginning percentage of each of the two local varieties by selection. An attempt should also be made to distribute seed of *Wagad* and *Kanvi* from the Dhrangadhra side, which produces better quality of cotton. At the same time arrangements should be made with the expert to test the suitability of Cambodia *under irrigation* and of imported Broach seed."

In this connection, the following letter was received from the Manager and Executive Engineer, Morvi State :—

" Mr. D. P. Mankad came here on the 3rd instant and stayed up to the 10th. He visited different Mahals of the State and made his journey on our tramway of a length of about 60 miles, where the principal crop is cotton. He was also shown the different varieties of cotton under trial in the State gardens. Thus every facility was given to him to visit the different parts of the State, so that he can send in his full report. I shall therefore feel very much obliged if you will kindly send me a copy of his report.

We are very much obliged to you for the help you have given us by sending Mr. Mankad, who was very busy here during his stay with his work and for this he also deserves our thanks in no less degree."

The Director of Agriculture, Baroda, submitted for valuation two samples of cotton grown in Kathiawar at Kodinar.

The first, of *New Orleans* type, was selected out of the prevailing mixture in the fields and grown separately to ascertain its value. The plot was flooded three times by heavy rain during the season. In spite of this a yield of 208 lbs. of seed cotton per acre was obtained, the ginning percent-

age being 30·3. The clean cotton was valued by Messrs. Tata, Sons & Co. at Rs. 315, compared with Sind American of the same date at Rs. 310.

The value of the second sample, which was a selected local *Mathio*, was Rs. 190, equal to fine *Mathio* of the day. No figures of outturn were supplied with this.

It has been suggested to the Director to repeat these trials during the present season.

Southern Mahratta Country.—The following notes were sent to the Director of Agriculture, Bombay, after an inspection of the cottons in the Southern Mahratta Country :—

" Dharwar.—There are now series of 10 generations of *Broach* cotton on this farm. The percentage has dropped to 29, which is, however, about 4 to 5 per cent. higher than the maximum of *Kumpta*, so that, judged on this point alone, it still leads.

Some members of the local Agricultural Association have offered to grow annually 300 acres of *Broach* from imported seed and to guarantee the distribution of seed only from cotton of the first class from this area, the standard to be fixed when lots are ginned to ascertain the percentage. This seems to be the most practicable plan to ensure the continuous supply of selected *Broach* seed in the District.

The longer growing season of *Broach* would always be a strong factor against the possibility of its ever supplanting *Kumpta* in any great degree. By steady selection the ginning percentage in *Kumpta* has been raised to 29, an advance of 4. It is quite possible that, by steadily aiming for percentage, a still further increase could be arrived at.

The cultivation of *Cambodia* has been abandoned at Dharwar. The crosses between *Soft Peruvian* and *Cambodia* are not promising after all; they seemed to have retained the perennial character and may fruit if held over for another season. As perennial cottons have

been proved unsuitable for conditions in India, there seems no good ground to justify the maintenance of these crosses.

One hundred pounds of selected *Kumpta* seed have been given out, but no results are yet available. It has been proved that the use of a fence of *Shervi* as a wind break is not practicable, as it exercises a distinctly bad influence on contiguous crops.

As far as I could gather, there is no dissatisfaction expressed regarding the quality of the imported Navasari seed this year.

Gadag.—This farm is now restricted to trials with American types of cotton. As at Dharwar, the cross between *Cambodia* and *Soft Peruvian* is not at all promising.

The whole of the *Cambodia* is now treated as being one variety, and the trials are directed with a view of keeping up the standard of staple and percentage.

The two forms of *Dharwar American*, which were isolated upon my advice last year, have been grown with a high percentage of purity. There is still a doubt as to whether the Upland or New Orleans type is superior. I am informed that some of the villages producing superior Dharwar American cotton are said to grow the New Orleans type exclusively. I have suggested that a fresh survey of these types in the district should be undertaken."

The following valuations were kindly supplied by Messrs. Tata, Sons & Co. :—

Valuations.

Basis of prices on 11th June 1914 :—

	Rs.
(1) Navasari	335
(2) Surat	320
(3) Madras Cambodia	310
(4) Kumpta	290
(5) Fine Broach	285
(6) Sawginned	265

Serial No.	Registered No.	Name.	Valuation.
		Dharwar Farm.	
1	1027A	Kumpta X Ghogari (Surat Cross)	We place them in the following orders as regards length of staple and general quality : first No. 2, second No. 3, third No. 4, and then No. 1. Of Nos. 5 and 6, No. 5 is better than No. 6. We value:—No. 1Rs. 305, No. 2 Rs. 325, No. 3 Rs. 320, No. 4 Rs. 305, No. 5 Rs. 300, No. 6 Rs. 295.
2	1364	Do. Dharwar Cross old	
3	2003	Do. Dharwar Cross new	
4	1339	Kumpta Cross	
5	...	Kumpta selected for quality	
6	...	Do. for quantity	
7	...	Broach, 1st generation (new seed)	Of these, No. 8 is the best. No. 7 comes next and rest are almost all more or less equal, though we find that Nos. 13, 14 and 15 are a little better than Nos. 9, 10, 11 and 12. We value:—No. 7 Rs. 310, No. 8 Rs. 315, No. 9 Rs. 300, No. 10 Rs. 300, No. 11 Rs. 300, No. 12 Rs. 300, No. 13 Rs. 305, No. 14 Rs. 305, No. 15 Rs. 305. Compared with No. 28, No. 7 is superior to it in length of staple, and is rather thin.
8	...	„ 2nd „	
9	...	„ 3rd „	
10	...	„ 4th „	
11	...	„ 5th „	
12	...	„ 6th „	
13	...	„ 7th „	
14	...	„ 8th „	
15	...	„ 9th „	
		(Old seed introduced in 1904.)	
16	2016	Kumpta X Comilla	The crossing has materially improved in the length and strength of staple over Assam. There seems to be no deterioration. If anything, it has improved. Value Rs. 285.
17	1027A	Kumpta X Ghogari	In crossing, it has obtained white colour of Ghogari and in staple it is ordinary Kumpta. Value Rs. 290.
18	1339	Kumpta Cross	It seems to have improved. Value Rs. 300.
19 & 21	...	Kumpta ordinary	Compared with Nos. 1 to 6, there can be no comparison with them, since both are very inferior as regards length and strength of staple. Of the two, No. 19 is superior to No. 21 which is even weaker than Kumpta in the local market. Value No. 19 at Rs. 280, and No. 21 at Rs. 260.
		„ „ from plot 608	

Serial No.	Registered No.	Name.	Valuation.
20	102E	Cambodia	The cotton is very weak in fibre and irregular in length. Value Rs. 280.
22	...	Cultivator's Kumpta . . .	It is no way superior to ordinary Kumpta, equal to local cotton. Value Rs. 290.
		Gadag Farm.	
23	...	Dharwar American (Green-seeded)	It is better than ordinary Sawginned coming in the local market. Value Rs. 280.
24	120E	Cambodia	This cotton seems to be little better than No. 20 of the Dharwar Farm, but still it is weak in fibre. Value Rs. 300.
25	1345	Christopher X Christopher .	It is longer in staple than No. 24, but equally weak. Value Rs. 310.
26	1356	Christopher X Culpepper . .	This is a very long stapled strong fibred cotton. Every way a desirable stuff. Value Rs. 360. This deserves to be widely cultivated.
27	...	Dharwar American (Gadag-Market sample).	This seems to be a mixture of Sawginned and Kumpta kappas. Hence there seems to be some strength in the fibre. Otherwise the cotton is of very inferior quality. Value Rs. 260.
		Gokak Farm.	
28	...	Broach New seed . . .	It is slightly inferior in length of staple than Navasari. Value Rs. 320.
29	1339	Kumpta Cross	It has improved in every way. Value Rs. 295.
30	...	Kumpta Ordinary . . .	It has lost in length of staple. Value Rs. 285.
31	102E	Cambodia	It has entirely deteriorated on the Gokak Farm. Value Rs. 275.
32	...	Cultivator's Kumpta (Arbhavi) .	It is better in length than farm Kumpta No. 30. Value Rs. 290.

Of four crossed cottons, *Kumpta X Ghogari* (Dharwar Cross old) was valued at Rs. 325; *Kumpta X Ghogari* (Dharwar Cross new) valued at Rs. 320; *Kumpta* Cross valued at Rs. 305; *Kumpta X Ghogari* (Surat Cross) valued at Rs. 305.

Kumpta selected for quality was valued at Rs. 300 and the same selected for quantity at Rs. 295. The samples of *Kumpta* ordinary cotton were valued at Rs. 280 and Rs. 260, thus testifying to the far higher value of the improved varieties given above. A sample of cultivator's cotton from Dharwar was valued at Rs. 290, equal to local cotton. Another *Kumpta* Cross was valued at Rs. 295. A sample of cultivator's *Kumpta* from Arbhavi was valued at Rs. 290. A sample of *Cambodia* from Dharwar Farm, where the conditions are unsuitable for it, was valued at Rs. 280 only, on account of its weak and irregular fibres; even a sample from the Gadag farm, where the conditions are far more favourable, was valued at Rs. 300 only. Green-seeded Dharwar American from the Gadag farm was valued at Rs. 280. A market sample from Gadag seemed to be a mixture of *Dharwar American* and *Kumpta*. It was valued at Rs. 260. Of the Upland Crosses, that of Christopher X Culpepper seems to hold the first position in value. Messrs. Tata remarked that this is a very long stapled, strong fibred cotton and, in every way, desirable stuff, which deserves to be widely cultivated. They valued it at Rs. 360.

Of the 9 generations of Broach cotton at the Dharwar Farm, Messrs. Tata valued 2 at the best, 1 as the second, and the rest more or less equal, though they found 7, 8, 9 a little better than 3, 4, 5, 6. Last year, it appeared that the deterioration was continuous, but, from this year's figures, it would appear that after thorough acclimatization perhaps an improvement may set in.

The auction sale of Broach Cotton.—The auction sale of *Broach* cotton was held at Dharwar on the 12th April 1914. In all 80,000 lbs. seed was distributed during the

year 1913-14 (30,000 lbs. seed imported from Navasari and 50,000 lbs. locally grown Broach cotton seed).

All the seed was not sown for want of timely rains, the approximate area sown would be between 4,000 and 5,000 acres.

Sowing commenced from the end of June to middle of July.

Season on the whole was not favourable either to Broach or to local cotton *Kumpta*.

There were no late rains and consequently cotton plants suffered.

In all 3,500 *dhokras* of *kapas* were received (4 *dhokras* are equal to 1 *Naga*, that is, equal to 1,344 lbs.) at the auction Depôt. I am informed by the Agent of Messrs. Tata, Sons & Co. that more than 300 *Nagas* were sold away by the cultivators before the auction sale for immediate requirement of money.

Broach cotton at the Depôt was graded in six classes according to ginning percentages.

The following prices were realised per *Naga* of 1,344 lbs. :—

Class.	Ginning percentage.	Price.
		Rs.
Special class—	34 and above	190
I	33·5	185
II	32·5	176
III	31·5	175
IV	30·5	171
V	29·5	155
Kapmta Cross . . .	27·5	139

The rate of the local cotton *Kumpta* on the day was Rs. 129 per *Naga*.

The low ginning percentage may be due to (*a*) the deterioration of the local cotton seed, (*b*) poor ginning percentage of the last pickings.

The representatives of the Bombay mill-owners and the local merchants who attended the sale were thoroughly pleased with the quality of cotton and believed that the stuff was similar to Navasari cotton except that the staple was rather rough and added that there will be no difficulty in realising good prices for this class of cotton up to 10,000 *Nagas*, and wished that the cultivation of this cotton should be extended.

There were no complaints regarding the quality of seed, but it is absolutely necessary to renew every year a large quantity of Navasari seed to keep up the standard of staple and ginning percentage.*

It is interesting to know that a man who had put out only 6 acres under *Broach* cotton, realised Rs. 574 at Rs. 95 per acre.

Cambodia Cotton.—The cultivation of this cotton has been tried in so many diverse localities that it is as well to collect all our scattered references under one head.

Guzerat.—Mr. Mankad has supplied the following note on Cambodia prospects in North Guzerat as the result of his inspection in November last :—

" Believing that the cultivation of *Cambodia* must have spread at Bawla, I went there on the 9th November, when I was informed that the cultivation was not undertaken during the present year.

The glowing report on this cotton is said to have had some effect in a village called Vasna in the Dholka Taluka and it is reported that a few acres have been put under this cotton. It is a fact that *Cambodia* seed in these parts was sold at an enhanced rate, 5 to 6 rupees per maund of 40 lbs.

* The ginning percentage this year, on the whole, seems to be high throughout.

The details of the three methods of cultivation of both, *Bhuri* and *Cambodia*, in the Goradu soil on the Nadiad Farm are as follows :—

(1) Start given by two waterings from May.

(2) Rain-fed.

(3) Two waterings to be given after the cessation of rains.

The new exotics were found attacked by wilt and aphides. White-ants had also destroyed a good many plants. Judging from the growth of the plants, the local cotton, *Lalio*, appeared more promising. *Bhuri* seems to be hardier and earlier in ripening (3 weeks) than *Cambodia*, but the low outturn combined with a low ginning percentage and a weak fibre are the greatest objections to it.

Cambodia tried at Shahpur near Petlad and at Cambay in the Kaira District also suffered from the attacks of leaf-rollers and aphides. The experimenters now report that the outturn is disappointing.

I am inclined to think that the following points do not seem to appeal in favour of *Cambodia*:—

(1) During the very first year of its trial in 1912-13 it gave a decidedly low ginning percentage on the Farm, and it seems doubtful whether it will keep up both in quality and ginning percentage; these two factors are of vital importance in the successful cultivation of cotton.

(2) Being a delicate variety, it is more susceptible to insect pests than the local cottons.

(3) Unless cultivation extends fairly on a large scale there seem small prospects of establishing a market for the disposal of this kind of cotton. It is also a question how far the product will be kept thoroughly pure.

(4) It seems difficult in practice to start the crop under one or two waterings in May to get good returns.

Irrigating the crop after the cessation of rains is likely to prolong the period of maturity."

In the Cambay State, 4 acres were put out, yielding at the rate of 140 lbs. seed cotton per acre. The sample of the clean cotton was submitted to Messrs. Tata, Sons & Co., who remarked that " the cotton seemed to be carelessly picked and ginned. It has retained the length of fibre and silkiness. We value it on Dhollera Basis Rs. 10 below Dhollera at Rs. 250. We may mention that if it had been carefully picked and ginned, it would have fetched Rs. 265 per candy."

In the Kaira District, at Shahpur also *Cambodia* was given a trial. The crop suffered badly from insects and no outturn figures were supplied, but the sample of the product was valued at Rs. 270, *Cambodia* on the day being at Rs. 290.

Dhrangadhra (Kathiawar).—Half an acre of *Cambodia* from seed supplied by us yielded 12 maunds and 30 seers (510 lbs. of seed cotton), as an irrigated crop, whereas *Kanvi* local cotton yields 10 maunds (equal to 400 lbs.) for half an acre in open fields; a mill-owner estimates that *Cambodia* would fetch 16 per cent. more than the price of the local cotton. A sample of this *Cambodia* cotton was reported on as follows by Messrs. Tata, Sons & Co. :—

" It is out and out superior and is the best *Cambodia* of the samples examined to-day. We value it at Rs. 320, equal to Navasari and Rs. 5 over the basis of Madras Cambodia."

Further trials are to be made this season in dry land.

The auction sale of Cambodia cotton.—The auction sale of *Cambodia* cotton took place on the 19th April at Gadag.

The area under this cotton was much limited during the year owing to its failure during the year 1912-13.

Purified Madras seed was distributed in the Gadag and Ron Talukas of the Dharwar District.

About 500 to 600 acres were grown under *Cambodia*. Sowing took place in the middle of September. The season was not favourable to any class of cotton and I am inclined to think from personal observations that *Cambodia* comes out well in a *bad season*.

In all 587 *Dhokras* (4 *Dhokras* make one *Naga* of 1,344 lbs.) were received at the auction Depôt.

The cotton was graded in 6 classes according to ginning percentages and realised the following prices per *Naga* of *kappas* (1,344 lbs.) :—

Class.	Ginning percentage.	Price.
		Rs.
Special Class purified	37 and above.	196
I	36·5	187
II	35·5	180
III	34·5	177
IV	33·5	172
V	32·5	166

Except the special class other classes may have an admixture of *Uppam* and *Karunganni* plants to a small extent and this may account for slightly low ginning percentage.

The local cotton *Dharwar American* on the day stood at Rs. 126 per *Naga* of 1,344 lbs.

N.B.—The cotton was perfectly clean but harsh to touch, staple also shorter than the standard of Cambodia.

The cotton of the special class was thoroughly purified by the Department and it is intended to distribute seed of this class only, together with that received from the Gadag Farm.

On the whole, the auction sale was a great success and *Cambodia* fetched very satisfactory prices. It is possible that the cultivation will considerably extend during the ensuing year.

Messrs. Tata, Sons & Co. have kindly furnished the actual valuations of all the five classes :—

	Rs.	
Special Class	275	Being ginned not in ordinary gins but in sawgins, the staple seems to have been cut and cotton presents a happy appearance. We value them on the basis of the value of sawginned at Rs. 270.
I „	280	
II „	290	
III „	270	
IV „	285	

Basis on 17th July 1914 :—

	Rs.
Madras Cambodia	315
Sawginned	270
Navasari	320
Kumpta	275

From the valuations, it will be seen that the trade appreciate the ginning percentage and not the quality so much.

As in former years, I have to thank Messrs. Tata, Sons & Co. for the care and trouble they have taken in furnishing valuations of the numerous samples of cotton submitted to them.

III.—Programme of work for the year 1914-15.

(1) To visit and advise on points regarding cotton and its cultivation whenever requested to do so by Provincial Departments of Agriculture.

(2) The study of the behaviour of *Bourbon*, *Bhuri*, *Cambodia* and other such cottons in non-cotton-producing tracts, as detailed in the last year's programme, will be continued.

(3) An enquiry on the manurial requirements of cotton will be continued.

(4) Researches on the botany of cotton will be continued.

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REPORT

OF THE

Agricultural Research Institute and College, Pusa.

(Including the Report of the Imperial Cotton Specialist)

1914-15

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Report of the Agricultural Research Institute and College, Pusa,

(Including the Report of the Imperial Cotton Specialist)

1914-15.

REPORT OF THE DIRECTOR.

(BERNARD COVENTRY, C.I.E.)

I. CHARGE AND STAFF.

Charge. I held charge of the office of Agricultural Adviser to the Government of India and Director, Agricultural Research Institute, Pusa, and Mr. Wynne Sayer, B.A., of the office of Assistant to the Agricultural Adviser to the Government of India throughout the year.

Mr. A. C. Dobbs, B.A., who was the permanent Assistant to the Agricultural Adviser was transferred to Ranchi as Deputy Director of Agriculture under the Government of Bihar and Orissa on the 26th April 1915 and Mr. Sayer has been appointed to the post.

Staff. The Chemical Section was in charge of Mr. J. W. Leather, V.D., F.I.C., during the year.

Mr. Jatindra Nath Sen, M.A., Supernumerary Agricultural Chemist, has been posted at the Agricultural College at Sabour since September 1914 for research work.

Mr. A. Howard, C.I.E., M.A., held the office of the Imperial Economic Botanist during the whole year. Gabrielle L. C. Howard, M.A., has been appointed as Second Imperial Economic Botanist, from 10th February 1915. As in previous years Mr. and Mrs. Howard proceeded to Quetta in May 1915 and will stay there for five months for work in connection with the development of the fruit industry in Baluchistan.

Dr. E. J. Butler, M.B., the Imperial Mycologist, was on leave during the year. Mr. F. J. F. Shaw, B.Sc., Supernumerary Mycologist, who has been appointed to officiate as Imperial Mycologist was in charge of the Mycological Section.

Mr. T. Bainbrigge Fletcher, F.E.S., F.Z.S., held charge of the Entomological Section.

Mr. A. J. Grove, M.Sc., Supernumerary Entomologist, was on deputation to the Punjab to carry out work on grain pests and cotton boll-worm till 27th April 1915 when his services were terminated on expiry of his probationary period.

Mr. F. M. Howlett, B.A., F.E.S., remained in charge of the Pathological Entomological Section during the year except for the period from 30th August to 22nd September 1914, when he was on privilege leave.

The Bacteriological Section was in charge of Mr. C. M. Hutchinson, B.A., throughout the year. Mr. J. H. Walton, B.A., B.Sc., Supernumerary Agricultural Bacteriologist, has been appointed to the Indian Army Reserve of Officers. He left Pusa on the 4th June 1915 to join his duties in the Military Department.

Mr. A. C. Dobbs, B.A., remained in charge of the Agricultural Section till 25th April 1915 when Mr. S. Milligan, M.A., B.Sc., on return from leave resumed charge of the duties of the Imperial Agriculturist. The two posts of Supernumerary Agriculturists are now vacant, as Mr. Sayer has been appointed as Assistant to the Agricultural Adviser to the Government of India from 26th April 1915, and the services of Mr. G. D. Mehta, L.Ag., B.A., Supernumerary Agriculturist, who was posted to Madras for training, were terminated on 31st March 1915, on the expiry of his probationary period.

II. Work of the Institute.

Scientific Work. The scientific work of the Institute during the period is indicated in the reports of the various sections.

Training. The post-graduate course students continued to receive training and short courses were also given in Sericulture and Lac culture.

The probationary research assistant under the Agricultural Chemist to the Punjab Government referred to in the last year's report completed his training in Agricultural Bacteriology during the year under report and the student deputed by the Department of Agriculture, Central Provinces, is under training in the same section. An assistant deputed by the Indian Tea Association is also under training in Agricultural Bacteriology.

In the Botanical Section a graduate of the Sabour Agricultural College deputed by the Bengal Department of Agriculture and a graduate of the Poona Agricultural College deputed by the Bombay Department of Agriculture completed their training in Botany during the year under report. The latter after finishing his course at this Institute has proceeded to England with a scholarship from the University of Bombay for further training in plant-breeding work.

A Fieldman deputed by the Principal, Agricultural College, Sabour, is undergoing training in Mycology in the Mycological Section.

In the Entomological Section an assistant deputed by the Punjab Government and a private student who is a graduate of the Lyallpur Agricultural College are under training in general Entomology.

Besides the regular students referred to above the following visitors also worked in the laboratories :—

Mr. B. L. Gupta, Professor of Biology, Reid Christian College, Lucknow, referred to in the last year's report, completed his course in Mycology and left on 8th July 1914. Mr. S. L. Ajrekar, B.A., Assistant Professor of Mycology, Poona Agricultural College, worked in the Mycological Laboratory from 28th October to 5th November 1914.

Mr. Awati worked in the laboratory of the Pathological Entomologist for some time at the taxonomics of *Muscidæ*.

III. Publications.

The Agricultural Journal of India, Scientific Memoirs and Bulletins continued to be issued during the year. The Department published during the year 13 Memoirs and 14 Bulletins. Of these a fair number was contributed by the Provincial Departments. The memoirs continued to maintain their standard of excellence and were much in request from scientific institutions abroad. The bulletins containing matters more of practical than scientific interest continued to be in good demand particularly in India. They covered a large range of subjects such as sugarcane crushing, sugar machinery and manufacture, bee-keeping, improvement of indigo cultivation and sericulture. Among these bulletins four were contributed by the Provincial Departments and one containing notes on sugar machinery and manufacture in Northern India is a report by Mr. Peter Abel, an authority on the manufacture of sugar, who toured in this country with a view to advise the Government of India in connection with sugar matters generally. The grant for publications amounting to Rs. 29,000 has been made permanent. It has been decided to publish a revised edition of the Manual of More Deadly Forms of Cattle Disease in India. This useful manual was last revised in 1903, and opportunity has been taken to bring it up to date and to practically rewrite it. This will considerably add to its utility.

As in the last two years, strictest economy was exercised with the result that it was possible to keep down expenditure within the sanctioned grant. But as the superior staff of the Department capable of making original investigations is continually increasing, the volume of matter offered for publication will tend to increase when the present grant will be found inadequate.

IV. General Administration.

Buildings and Works. During the year under report the construction of two additional bungalows for European officers and the extension of the Pusa Library were completed. Additional quarters for the subordinate staff of the Institute are under construction. The schemes for the installation of electric lights and fans in the European bungalows and the Rest House at Pusa and for the addition of a female ward to the Pusa hospital as well as the proposal for a new ice machine at Pusa have been sanctioned.

Library. The third edition of the catalogue of the Pusa Library will shortly be out. During the year under report over 500 volumes were added by purchase besides many foreign bulletins, memoirs, reports, etc., which are received in exchange from different parts of the world.

Pusa Schools. The Middle English School was raised to the status of a High School on 2nd January 1915, and one of the long felt wants of the residents was thus satisfied. The number of pupils attending the school at the close of the year was 185. It has a staff of one Head Master and 14 Assistant Masters and promises success. A Lower Primary Girls' School was also started on 20th February 1915.

General Health of the Station. The general health of the station during the year under report continued to be good. Medical relief was afforded to 10,217 persons of whom 9,969 were treated in the out-patients' department and 248 admitted as indoor-patients. Ninety-one cases among the European officers and their families were attended to.

The daily average number of patients treated was 69·19 out-door and 12·14 in-door.

Ten deaths occurred in hospital, some of these cases were brought to the hospital in rather advanced stages of disease.

The epidemic of cholera, which broke out in the villages in the immediate vicinity of Pusa during the months of May and June, threatened to be a source of great danger. Immediate and successful measures were taken to prevent its entering the Estate, the chief of which was keeping of the water supply pure by disinfecting and cleaning of the wells.

One hundred and ninety-eight surgical operations were performed of which 27 cases were major and 171 minor.

Fourteen primary and four re-vaccinations were performed during the year.

V. Accounts.

The total expenditure during the financial year 1914-15 was Rs. 4,79,825 as under :—

	Rs.
Office of the Agricultural Adviser to the Government of India and Director of the Institute	2,03,046
Chemical Section	41,807
Mycological Section	25,015
Entomological Section	43,142
Pathological Entomological Section	25,662
Botanical Section.	38,220
Bacteriological Section	31,592
Agricultural Section	71,341
Total	4,79,825

Out of the grant of Rs. 1,10,000 for the development of the Indian Sugar Industry referred to in previous year's report, a sum of Rs. 35,000 was provided in the budget for 1914-15 for meeting the expenditure in connection with the engagement of Mr. W. Hulme as Sugar Engineer in the United Provinces.

A sum of Rs. 15,000 was paid as grant-in-aid to the Indian Tea Association.

The principal items of expenditure under the annual grant of Rs. 10,000 placed at the disposal of the Agricul-

tural Adviser to the Government of India for special Agricultural Experiments were as follows :—

	Rs.
Purchase of two Ayrshire bulls for the Pusa Farm and the Agricultural Department, Central Provinces	1,920
Contribution to the Bacteriological Section .	1,030
Distribution of Pusa wheat seed No. 12 in the United Provinces	4,000
Experimental cotton cultivation conducted by the Imperial Cotton Specialist . . .	1,500
Purchase of silk yarn for sericulture experiments at Pusa	240

The gross receipts during the year from the sale of farm produce, milk, publications of this Department and other articles amounted to Rs. 16,843 as against Rs. 22,157 of the previous year.

VI. Visitors.

During the year under report His Highness the Maharaja Bahadur of Darbhanga, the Hon'ble Sir Robert Carlyle, K.C.S.I., C.I.E., I.C.S., Member-in-Charge of Revenue and Agriculture, Government of India, the Hon'ble Mr. Lallubhai Samaldas, C.I.E., Member of the Legislative Council of the Government of Bombay and Mr. A. E. English, C.I.E., Registrar of Co-operative Societies, Burma, and many others visited the Institute.

REPORT OF THE IMPERIAL AGRICULTURIST.

(S. MILLIGAN, M.A., B.Sc.)

I. ADMINISTRATION AND TOURS.

Mr. Dobbs continued in charge of the Agricultural Section until my return from combined leave on April 25th, 1915.

The number of the Supernumerary Staff has been reduced to *nil* owing to the termination of Mr. Mehta's agreement and the appointment of Mr. Sayer to the post of Assistant to the Agricultural Adviser.

Mr. McLean, Deputy Director of Agriculture, Bengal, and Mr. D. R. Sethi, Deputy Director of Agriculture, Bihar and Orissa, were posted to Pusa for preliminary training for periods of three and four months respectively.

Mr. Judah Hyam, Veterinary Overseer, continued in charge of the breeding herds. Mr. L. S. Joseph, Veterinary Assistant, acted for him in addition to his own duties for one month.

Mr. Md. Ikramuddin held the post of 1st Farm Overseer during the year. He was on privilege leave for three months from 2nd January to 31st March 1915.

Mr. Arjan Singh held the post of the 2nd Farm Overseer throughout the year and officiated for the 1st Farm Overseer for three months from 2nd January to 31st March 1915 in addition to his own duties.

Babu Brajaraj Mukerji, Fieldman, was promoted to the post of senior fieldman from 1st April 1915.

Mr. Imdad Hoossain Khan has been appointed as a Fieldman on Rs. 50—5—75 on probation for three months from 15th May 1915.

Mr. Dobbs visited Ranchi in October 1914 and the agricultural stations of Bengal, Bihar and Orissa, and the Central Provinces in December and January.

Mr. K. P. Roy from Bengal, attended the general course of instruction in Agriculture from 4th June to 16th September 1914.

II. Farm Cultivation.

Character of the season. The total rainfall of the season (June 1914 to May 1915) amounted to 54·88 inches. An abnormally heavy fall in August (28 inches) caused serious flooding in the lower lands and affected both the standing crops and the ensuing *rabi* crops.

Crop Experiments. The field experiments dealing with the maintenance of soil fertility under a double cropping system (*i.e.*, two crops per annum) by the use of manures, have been continued. The green manuring experiments in collaboration with the Imperial Agricultural Bacteriologist have been altered in accordance with the experience gained. A large expansion of "quantitative" experimental work will not be possible for a few years until the land recently laid out for this purpose has been properly tested.

Cultivation. The Fowler's double engine tackle purchased in 1913 has proved its suitability to special circumstances with careful supervision. As was pointed out by Mr. Dobbs in last year's report Pusa Farm is far from being ideal for the use of such machinery and much better economic results could undoubtedly be obtained under more favourable conditions. The tackle is, however, of particular value at Pusa, with its large area under crop, in lightening the work of the supervising staff, and allowing of more concentration on experimental work and necessary improvements. The writer considers it premature to express any definite opinion as to the economic value of such tackle until correct figures can be worked out for depreciation and repairs which cannot be done while the machinery is new.

Trials of a new type of motor plough were undertaken for the makers. Some modifications of the engine to suit

the Indian climate have proved necessary and are being introduced.

III. Live-Stock.

Cattle Breeding. As mentioned in last year's annual report two herds are now being maintained at Pusa one of selected Sanhiwal (Montgomery) cows and their descendants, the other of cross-bred Ayrshire-Sanhiwal cattle.

As the breeding operations have since 1912 been based entirely on the milk records of the females the initial steps have been completed towards the building up of "milk pedigree" but results will not be apparent until the calves of the present generation have grown up.

The cross-breeding operations with imported bulls must be considered as purely experimental, the primary object being to gain information regarding the transmission of characters, valuable or otherwise, of the exotic breed.

Sheep Breeding. The operations as described in last year's report, *viz.*, the crossing of local sheep with Merinos with a view to gaining information regarding the inheritance of wool characters, have been continued. There is nothing to report as the second generation of cross-breds has not yet been produced.

IV. General.

Drainage. A new protective drainage scheme has been completed. The Pusa Estate has now been provided with its own outlet to the river and a pumping station has been erected to deal with excess water in times of high river levels.

The main drains of the low-lying area have been enlarged. New roads have been made to improve the shape of the fields and a new field added to the experimental area. Experiments in puddling rice land with steam disc harrows are in progress and arrangements have been made to control the irrigation and drainage of the rice area.

V. Programme of work for 1915-16.

The following are the lines of work in progress :—

Major investigations.

1. The economics of cultivation by steam and motor engines.
2. The puddling of rice land by the double engine system of steam cultivation.
3. The combination of irrigation and drainage in the growing of rice.
4. A study of inheritance of the more important characters of dairy cattle by crossing.
5. The building up of milk pedigree in cattle by selection.

Minor investigations.

6. The inheritance of wool characters in sheep.
7. Experimental tillage in the growing of maize and sugarcane.
8. Improvement of pastures.

REPORT OF THE IMPERIAL AGRICULTURAL CHEMIST.

(J. WALTER LEATHER, V.D., F.I.C.)

I. ADMINISTRATION AND TOURS.

Charge. The section was in my charge during the whole year.

Establishment. Mr. Jatindranath Sen, the Supernumerary Agricultural Chemist, was posted to work at Sabour from September 1914.

Babu Surendra Lal Das Gupta, M.Sc., was appointed a probationary assistant on 6th February 1915 and he promises to prove a useful addition to the staff.

Babu Debendra Nath Chatterjee has been transferred to the office of the Chemical Examiner and Bacteriologist, United Provinces, from 7th June 1915.

Babu Mahabir Prasad was appointed a probationary assistant from 6th April 1915, but has reverted to the Education Department of the United Provinces.

Mr. G. K. Lele was dismissed in November 1914.

Tours. The following tours were made by me :—

1. September 1st to 9th. To Indore to advise as to the nature of the local soils.
2. September 12th to October 18th. Hill recess, when a memoir on Soil Temperatures was written.
3. November 4th to 20th. Tests of the freezing points of milks were made at the military dairies at Lucknow and Allahabad. I also attended the camp-of-exercise of the United Provinces Horse.
4. December 29th to January 10th. I visited Peshawar in order to test sugarcane at the time it was put into clamps.
5. March 13th to 28th. I visited Peshawar again to test the sugarcane when being taken out of the clamps.

II. Education.

No students have been admitted during the past year.

III. Meteorology.

In addition to the usual records for the Meteorological Department, records of (*a*) soil temperatures, (*b*) drainage, and (*c*) pressure by means of a barograph have been maintained.

IV. Soil Problems.

Soil temperatures. The temperature of the soil is well known to have an important influence on the soil, chemically and physically, but perhaps more especially on its biological activity, both with respect to the higher plant and lower organism. Moreover, since plant growth is principally confined to the upper two or three feet of soil, it is the temperature, and the temperature change, occurring in this stratum which is of importance. Several records of soil temperature have been maintained by the Meteorological and Survey Departments, but these have related rather to the temperature change of considerable depths than to that of the uppermost soil. For these reasons it was decided in 1910 to maintain such a record at Pusa. The soil being a bad conductor of heat, it is to be expected that the chief diurnal temperature changes will occur within the first few inches. It was then evident that for a record of soil temperature to be of service, it must relate to planes near to the soil surface. The nature of the soil-surface had also to be considered. Commonly this is rough, including lumps of earth varying from one to several inches in diameter with open spaces between them. How would such an irregular surface affect a thermometrical instrument ? A further primary question was what effect would a growing crop have on soil-temperature changes ? It was originally desired to ascertain the temperature changes for exposed soil (*a*) with a plain surface and (*b*) with a rough one, as well as for land bearing crops, but preliminary work showed that the diurnal variation in the first 3″ of soil was so great that an irregularity of 1″ caused

by the presence or absence of any odd piece of earth over the thermometer, would seriously impair the record; that indeed it would be necessary to know the distance from the surface to the instrument to within 0·1″ if the record was to be at all correct with reference to depth below the surface. For example, if two thermometers were placed at a nominal depth of 2″ below the surface, and owing to rough cultivation of the soil above them, the actual depth or thickness of soil were altered to 1·5″ and 2·5″ respectively, these two instruments instead of registering the same temperature, say at midday, would actually show a difference of more than 1° C. The rough cultivation commonly employed throughout India in the hot weather, which has been styled "hot weather weathering," implies a surface much more irregular than that just exemplified, and it was almost immediately clear that any record which was maintained below a roughly cultivated surface would be valueless because of the impossibility to define the distance from the surface to the instrument. The records maintained at Pusa have referred to the soil below (*i*) a smooth bare-fallow surface, and (*ii*) a similar surface on which crops were growing. The instruments employed were self-registering mercurial and alcohol thermometers of a good make, the errors being determined periodically. They were placed in tubes running horizontally below the soil surface at 1″, 2″, 3″, 6″, 9″, 12″, 18″, and 24″ deep. This arrangement is not what has been usual when observing soil temperatures, instruments being commonly inserted vertically into the soil. The latter is open to criticism in several respects; the instruments are exposed to the sun, they will generally possess a different, and often greater conductivity than the soil; the thermometer bulbs or sensitive part of a pyrometer indicates the mean temperature of the soil stratum in which it rests, and not that of a plain which is actually what is desired; if then the instrument is placed horizontally, this soil stratum is considerably thinner than if it is placed vertically in the soil, that is, this source of error is reduced.

The information has been published as a *Memoir of the Department of Agriculture in India* (*Chemical Series*, Vol. IV, No. 2) and the principal items of information are as follows:—

(*a*) *In bare-fallow soil.* (*i*) There are naturally both diurnal and seasonal changes of temperature. The former extends to between 1 ft. and 2 ft. from the surface; at 1 ft. deep it amounts about 1° C., but at 2 ft. it is doubtful whether it ever exceeds 0·1° C. in Bihar and probably never exceeds 0·2° C. in any part of India. Near the surface the diurnal change is very considerable. The seasonal change at 2 ft. deep amounts to about 13° C. The minimum temperature occurs in January and the maximum in May.

(*ii*) There is a fairly close correspondence between the soil temperature at 1″ deep, in bare-fallow soil, and the air (shade) temperature; approximately the soil-minimum is 2° higher and the soil-maximum 3° higher than the air temperature.

(*iii*) There is a similar relation between the *diurnal change* of temperature in the soil and air; at 1″ deep this change is about 1·5° C. greater in the soil than in the air. This diurnal change is least during the monsoon and greatest during the dry season, as is the case in the air. The amount of the change varies from 10° C. to 20° C.

(*iv*) Regarding the soil-temperature *at* the surface this could not be ascertained directly, but judging by collateral evidence, with a clear sky it probably rises to about 20° C. higher than the air (shade) maximum temperature during the day, and falls to approximately the air minimum at night.

(*v*) The above relations are substantially independent of season, and since the range of temperatures at Pusa is considerable, it seems reasonable to

conclude that they would apply to soils generally in India.

(*vi*) The temperature of the soil near the surface, (down to 3″ or 4″) is above the mean temperature for only about 8 hours and below it for about 16 hours.

(*vii*) The lag in temperature change is about 2 hours at 3″ deep and about 8 hours at 18″ deep.

(*viii*) A change in the specific heat and conductivity of the soil due to change of proportion of water, does not always affect the maxima and minima. During the monsoon period when the soil contains very much more water than during the dry season, and when both its specific heat and conductivity are consequently very much greater, the relation between soil temperature and air (shade) temperature remains substantially unaltered. That a wet soil requires considerably more heat to raise its temperature 1° C. than does a dry soil is of course well understood, but apparently the period of exposure is sufficiently great to allow the soil's temperature to assume during the day or the night the same relation to the air temperature whether it is wet or dry; the effect of increased conductivity counterbalancing that of increased specific heat. If, however, a heavy shower of rain falls on the desiccated soil of the hot weather, the conditions are different. Such showers are accompanied by a marked fall of air maximum temperature and the soil-maximum falls in a corresponding degree. But the air humidity at this season rapidly falls after such showers and evaporation of moisture from the soil increases very greatly, causing a marked change in the soil-minimum.

(*b*) *In cropped land.* The effect of a covering crop on the soil-temperature is naturally very marked,

for it both prevents the surface soil from rising to the temperature which fallow land assumes, and also modifies the diurnal change. Thus whilst the temperature of exposed soil at 1″ deep rises to about 3° C. *above* that of the air, that of cropped land is about 2° C. below it; and whilst the temperature of exposed soil *at the surface* rises to probably some 20° C. above that of the air, the corresponding figure for cropped land is only some 2° or 3° C. even in March, whilst in the rains it is actually lower than the air. Also in respect of diurnal change; at 1″ deep, whilst exposed soil suffers a change of some 20° C. in March, that of cropped land is only about 13° C. at the same depth; and during the monsoon whilst exposed soil suffers a diurnal change of some 10° C. at 1″ deep, that of cropped land is only about 3° to 4° C.

Soil gases. For some time attempts have been made at Pusa to devise an apparatus by the aid of which the gases contained in a portion of undisturbed soil, taken from a specified depth, might be extracted, measured and analysed. Hitherto the gases contained in soils have been separated for analysis by inserting a tube into the soil and aspirating a portion of gas out of it. By this latter method contamination with the outside air is possible, the real situation from which the gases flow into the tube is uncertain, and the direct measurement of the gas per unit volume of soil is impossible. But if a portion of undisturbed soil could be taken from the field in a tool which could be subsequently closed and provision made for attaching this to a pump, the volume of gas so obtained could be compared with the volume of the soil specimen taken from a specified depth and contamination with atmospheric air would be excluded. Although an apparatus for this purpose was designed several years ago and employed on some preliminary work on soil gases, it was not free from imperfec-

tions, and the more perfect one which has been employed for recent investigations was only designed and made in 1913. By its aid the gases contained in a known volume of soil taken from a specified depth below the surface can be separated, measured and analysed.

One of the first questions that occurs is whether a finely divided material like a soil condenses much gas on its surface. A volume of soil will include mineral and organic matter, water and gases. The volume of soil in the apparatus above referred to can be measured; the volumes of the solid material, and of the water can be derived from their weight and density, that of the gas which is extracted can be measured. Some of the latter will be in solution in the water, but the volume of this can be calculated. Thus these various measurements yield on the one hand the volume of the soil; on the other the volumes of solid material, water, gases. If there were no condensation of gas by the soil material, the sum of the latter would equal the volume of the soil *in situ*. But if the soil material is able to condense gases, the sum of the several constituents will exceed that of the soil. The measurements are naturally accompanied by some errors and it is not possible to say that the Pusa soil condenses no gas, but the proportion is certainly very small and is less than 4 per cent. of the total gas present.

The amount of gas which the water in the soil dissolves is of great interest. In dry land soils, the only gas which dissolves to any material extent is carbon dioxide, the volumes of dissolved oxygen and nitrogen being too small to be of any consequence. By the aid of the work[1] on the bicarbonates of calcium and magnesium which was done in this laboratory by myself and Mr. Sen, it is possible to calculate how much of the carbon dioxide is dissolved and in the gaseous state in the soil respectively. In fallow soil in all ordinary conditions very much the greater part of the carbon dioxide is in the dissolved state.

[1] *Mem. Dept. Agric. Ind.*, vol. I, no. 7, and vol. III, no. 8.

In the case of swamp paddy soil gases, the amount of dissolved oxygen and nitrogen has an important bearing. Messrs. Harrison and Subramania Aiyer have given reasons[1] for assuming that the dissolved oxygen is of importance both to the surface film and to the roots of the plant below. Calculations regarding the sources of the nitrogen in the gases have shown that probably about one-third of it is derived from the dissolved nitrogen of the irrigation water.

Regarding the examination of soil gases generally it is of importance not merely to ascertain the proportions of oxygen and carbon dioxide present. Although our knowledge of the biology of the soil is so imperfect, the general conclusion that oxygen is commonly used up in the production of carbon dioxide is no doubt justified, but the ordinary gas analysis might not show whether oxygen was being utilized in other ways. Again percentages of oxygen and nitrogen do not themselves show whether there has been an absorption of the one or an evolution of the other. For example supposing nitrogen gas were being liberated the effect would be an increased per cent. N, a decreased per cent. O; but these figures would not show whether oxygen was being absorbed by the soil or nitrogen liberated. An important case of this nature is the origin of the nitrogen in paddy land gases. Messrs. Harrison and Subramania Aiyer after discussing the matter[2] by means of indirect evidence, concluded that a part of the nitrogen in these gases was derived from the organic matters of the soil and manure, but a means of directly testing the question was clearly of importance. Such a question could be solved by the estimation of a gaseous element which takes no part in biological processes. The gases present in the soil are derived from (*i*) the outside atmosphere and (*ii*) the products of biochemical change. Hence if the nitrogen in the soil were derived solely from the atmosphere, its ratio to the rarer elements, argon, helium, etc., in the soil gases should be the same as in the atmosphere, whilst if nitrogen

[1] *Mem. Dept. Agric. Ind.*, vol. III, no. 3, p. 81.
[2] *Loc. cit.*, p. 82.

gas were being produced from organic matters or if it were being assimilated by a plant, its ratio to the rarer elements would be altered. The estimation of the proportion of argon in soil gases offered a probable solution of some of the above indicated questions. Argon takes no part in animal or vegetable economy, and except for very slight possible alterations due to diffusion, its ratio to oxygen and nitrogen in the soil would be the same as that in the air, unless these latter gases were absorbed or liberated during biochemical change. The atmosphere contains only 0·93 per cent. A against about 79 per cent. N, and since the accuracy of the estimation of the one depends on that of the other, the probable error in the ratio is not inconsiderable, but nevertheless as an aid to the examination of soil gases, the argon determination has proved of great use.

Mr. Harrison very kindly sent me samples of the gases obtained from paddy lands and the result of the analyses was to show quite conclusively that nitrogen gas is liberated in these lands from the organic matters. The N : A ratio in atmospheric air is 83, whilst those found in the paddy land gas varied from 92 to 98. Moreover it has to be realized that the outside air is so perfectly excluded that, apart from any nitrogen evolution in the soil, the nitrogen and argon in these gases are largely derived from the dissolved gases in the water, in which the N : A ratio is 33. Hence the conclusion was admissible that a high proportion of the nitrogen in these gases is derived from the decomposition of the organic matters.

In other cases the N : A ratio has not proved so serviceable as was at first hoped. The assimilation of nitrogen gas by *Papilionaceæ* is a case in point. It is usually assumed that the assimilation, by these plants of a part of their nitrogen is effected indirectly by the agency of the bacterium, *Bac. radicicola* in the root nodules, but the assumption lacks direct experimental proof. Allowing the truth of the assumption, then the N : A ratio would fall in the gases present in the neighbourhood of the roots of such plants. As a matter of fact nearly all the N : A ratios

found for samples of such gases were low, but unfortunately it is not possible to determine this ratio very precisely, and the difference actually found had to be referred to probable error. In addition, subsequent considerations of the quantities of nitrogen involved indicated that it is doubtful if the question of the assimilation of this element by the roots of *Papilionaceæ* can be solved by the N : A ratio.

Another question naturally arises, namely, whether other gases than carbon dioxide or nitrogen are produced in soils ? The gases of swamp rice-land include much hydrogen and methane, but the conditions are anaerobic and the general opinion has been that in ordinary dry-land soils such gases would not be produced. For example recent samples of gases from Rothamsted soils[1] were found to be free, or substantially free, from hydrogen and hydrocarbons. In some of the Pusa soil gases small, though well defined, amounts of hydrogen were present. This was the case particularly in the neighbourhood of the roots of crops, san hemp, indigo, maize, and must be referred to bacterial activity. In the same situations very large proportions, 16 to 20 per cent., of carbon dioxide, and low proportions—2 to 4 per cent.—of oxygen were found. Such proportions of these gases have not been met with elsewhere in the neighbourhood of crops, but it is to be recollected that the subject is one which has been hardly investigated hitherto and indicates a very intensive activity of lower organisms at least during the monsoon in India.

The conditions during a period of rapid nitrate formation are again very interesting. When discussing the drainage of rain water through soils, [2] evidence was adduced showing that intensive nitrification in the first few inches of soil followed immediately after the first heavy rain of the monsoon, in 1910; this occurred similarly in 1911 and 1914. During this process considerable amounts of oxygen are required, and calculation showed that this

[1] *Jour. Agric. Sci.*, VII, 4.

[2] *Mem. Dept. Agric. Ind., Chemical Series*, vol. II, no. 2.

oxygen could hardly be accounted for by that which was present in the soil. Other experiments showed that this soil utilizes under such conditions even much more oxygen than that required for the nitrate formation. On the other hand analyses of the gases in 1914 showed that despite the large amount of oxygen required, the percentage of this element in the soil was nearly normal. It became evident therefore that a sufficient supply of oxygen must have been diffusing into the soil from the atmosphere.

The process of diffusion of gases through soils has been generally believed to be a very slow one. Direct experimental evidence on the subject is limited to that of E. Buckingham [1] who concluded that there was a direct relation between the "porosity" of a soil and the rate at which gases could diffuse through it. The "porosity" he defined as that fraction of the whole volume of soil which is occupied by gases. He defined any particular portion of soil as unity and the "porosity" is therefore less than unity. Soils commonly include as gas some 20 to 40 per cent. of their volume, and the "porosity" in such cases varies from 0·2 to 0·4. Buckingham considered that the equation:

$$D = K S^2$$

was sufficiently accurate to define the quantity of a gas diffusing through a known column, (or depth) of soil, under known gradient; and that this quantity is less than would diffuse if no soil were present by the square of the porosity. The results of such experimental work should, if possible, be checked by independent evidence, but the difficulty is to provide such independent evidence.

Buckingham's equation was applied to several of the cases which have formed the subject of the work on soil gases at Pusa, and in some respects at least it is supported. For example where green manure was applied during the monsoon, the calculation showed that 0·0658 c. dm. of CO_2 was leaving the soil per sq. dm. per day during the first 10

[1] Contributions to our knowledge of the aeration of soils by E. Buckingham; *U. S. Dept. Agri. Bur. soils, Bull.* no. 25, Washington, 1904.

days. Assuming a uniform rate of decomposition, the whole of the green manure would be oxidized in about 95 days. There is, however, reason to suppose that the rate would fall off as time went on, so that as an independent test of the reliability of the equation, it may be considered to support it very well. Again the calculated amount of carbon dioxide production in soils in which nitrification was in progress agreed very fairly with what was experimentally determined under controlled conditions in the laboratory. On the other hand calculations for the volumes of oxygen diffusing into the soil yielded unexpectedly high figures. One cannot go further with the matter at present, but it is at least certain that the process is a much more rapid one than is commonly supposed.

The value of good cultivation of the surface soil has been usually attributed to the fact that by stirring the soil, gaseous interchange is suitably accelerated, carbon dioxide is allowed to escape and oxygen to enter. It is often easy to suggest an explanation which on paper bears the necessary "hall-mark," but it is somewhat remarkable that among the many who have accepted this explanation for the advantage of good cultivation, none appears to have considered that much deeper stratum of soil—several feet in thickness—which is never disturbed by cultivating implements but in which crop roots develop freely and which it is equally necessary to aerate. If for efficient gaseous interchange it is necessary to plough the top 6″, it should be similarly necessary to plough the succeeding several feet of soil! So long as one is content to accept the proved value of good cultivation without attempting to give explanations for its advantage, the position is unassailable; but if one goes further and states that the explanation is that thereby objectionable carbonic acid is released from or valuable oxygen admitted into the soil, the premises are very readily open to criticism. Even allowing Buckingham's experimental work to have been a good deal in error, the consideration of the cases which have been examined at Pusa shows that, so far as aeration is concerned, the culti-

vation of the surface soil might be omitted altogether; its well established value must be referred to other causes.

A memoir on the subject is now in the press.

V. MANURES.

Village ashes. Owing to the war the supply of potash salts from Stassfurt has ceased and since these mines have formed the chief source of the world's potash supply for a number of decades, the price of all potash salts has risen seriously.

India is not a large consumer of potash salts, but there is a small steady demand for such among the tea and coffee planters of Southern India, and it was thought to be worth while to examine samples of village ashes obtained from the several provinces in order to ascertain whether potash could be economically extracted from them. Seventeen samples were examined and the percentage of potash varied from about 1 to 10 per cent. From one quarter to two-thirds of this is frequently soluble in water. The remainder could be extracted by the agency of strong acid, but this could not possibly pay. The water soluble potash could be readily and very cheaply extracted in a manner similar to that employed for the extraction of saltpetre from earths. The evaporation of the water, in order to obtain the crude potash salt, would require relatively a good deal more fuel than is required for the evaporation of the crude saltpetre liquors, and since the crude potash salts obtained per 100 lb. of water evaporated would not be worth nearly as much as the corresponding quantity of crude saltpetre, and since also the latter operation hardly pays the *nuniah* to continue his industry, I concluded that it is very doubtful if the manufacture of crude potash salt from village ashes could succeed.

It seems probable that tea and coffee planters who require potash salts could most readily supply the present deficiency by either burning waste timber on their own estates or by doing so in the nearest forest, and putting the wood ashes direct on the land, or possibly after first

treating the ashes with a limited amount of sulphuric acid. A note has been submitted on this subject.[1]

VI. Saltpetre.

The experiments on the improvement in methods for refining saltpetre have progressed considerably during the past year and there is now every reason to hope that by the use of a filter press and other appliances the outturn of refined saltpetre will be considerably greater than is usually obtained by refiners.

VII. Feeding Stuffs.

A considerable number of specimens of cattle foods have been analysed during the year more particularly on behalf of the military authorities. It is intended to issue these and other analyses shortly in the form of a bulletin.

VIII. Sugar.

Sugarcane. The nature of the sugar investigations which have been in progress during the past three years at Tarnab, Peshawar, was explained at length in my last annual report. The only additional work which has been done during the past year consisted in a test, on a large scale, of the safety of "clamping" large quantities of sugarcane. It will be recollected that from the manufacturing point of view the advantage of being possibly able to preserve sugarcane over the months of February to April was recognized and experiments with small lots of sugarcane were made during the cold weather of 1913-14. These indicated that the local sugarcane could be so preserved until at least sometime in March without suffering serious depreciation. It had to be recognized, however, that in order to draw a safe deduction the tests should be made with large quantities of cane such as would probably occur in practice, because the conditions in small heaps would be different in some respects; the weight of cane in a large heap would subject the cane at the bottom to a greater

[1] *Indian Trade Jour.* July 23rd, 1915.

pressure than would occur in a small heap; the care which could be economically devoted to the handling of a large quantity of cane might not be sufficient to prevent considerable breakage of cane, resulting in a possibly serious amount of rotting; it was also desirable to estimate the cost of clamping.

Accordingly Mr. Robertson Brown arranged to clamp two lots of sugarcane in January, the one from approximately an acre and weighing about 20 tons, the other from half an acre and weighing about 16 tons. The former was "striped Mauritius," the latter "local *pounda*" cane. These two lots of cane were put into the clamps during the 1st week of January and the clamps were opened and tested during the third week of March, that is after a period of about 10 weeks. In the following table the chief data are set out, from which it will be seen that the amount of change suffered by the cane was nominal.

	Striped Mauritius		Local *pounda*	
	January	March	January	March
Weight per cane (lb.)	1·74	1·79	1·78	1·91
Juice per cent.	71·6	65·7	73·1	71·1
Sucrose (per 100 parts of juice.)	13·19	12·11	12·34	11·20
Invert sugar (per 100 parts of juice.)	0·83	0·73	1·29	1·04
Brix	16·1	14·8	15·3	14·5
Co-efficient of purity	84·7	84·6	83·6	81·5

These two experiments leave no doubt that sugarcane can be safely preserved in clamps until the end of March at Peshawar without suffering any serious loss. The number of canes which rotted in the clamp was very small; rotting was quite definitely restricted to cane which had been accidentally cut or broken and did not extend beyond the originally damaged part, nor did it spread to sound cane. No sound cane was damaged at all.

Mr. Robertson Brown and the writer have discussed the practicability of employing this process on the large scale for the advantage of a factory. There is no doubt that it is rather more troublesome to take cane up by the roots than to cut it off; there is also the cost of putting the cane into clamps, and the cost of taking it out again. Altogether apparently this increased cost would come to about one anna per maund of cane. On the other hand it is to be realized that a factory situated in this part of India could certainly afford to pay somewhat more for cane in February and March rather than stop working altogether, for in the latter event the whole of the more expensive staff is kept idle and the daily paid labour becomes dispersed. It is therefore by no means necessarily the case that because it costs something to put cane into clamps, it would not pay everyone concerned to employ the process.

Estimates were obtained during the year for a small sugar factory fitted for working beet and cane and capable of producing from 1 to 2 tons of sugar per day. These were submitted to the Agricultural Officer, North-West Frontier Province. Briefly the factory would cost about Rs. 1,50,000 erected; the annual running charges would come to :—

	Rs.
Wages, etc.	10,000
Cost of 900 tons of cane . . .	9,150
Cost of 900 tons of beet	10,800
	29,950

whilst the value of sugar produced (155 tons) would be about Rs. 33,480. The total sugar annually imported into the North-West Frontier Province is about 9,000 tons which is either consumed locally or re-exported to other frontier countries. Some of this sugar could be easily grown and manufactured locally without in any way seriously affecting the local production of *gur*, which is considerably greater, namely, about 35,000 tons.

Cocoa-nut "milk." At the request of the Chief Commissioner of the Andamans and Nicobar Islands the milk of cocoa-nuts was examined with a view to ascertaining whether it possesses potential commercial possibilities. About twelve lakhs of nuts are utilized annually in the Jail, but for the milk there is no commercial outlet and it is thrown away. It is only a weak solution of sugars and other carbohydrates with small amounts of proteids. The sample sent to Pusa contained 0·187lb. sucrose, 0·056lb. glucose and 0·258lb. of other matters, mostly gums, per gallon of the milk. Boiled down to the dry state it formed a very pleasant tasting "toffee," but it could not possibly pay to conduct this process on the manufacturing scale.

IX. Starch.

During the year my attention has been directed to the possibility of economically manufacturing starch from Indian materials. One of the results of the war has been to cut off some of the usual sources of manufactured starch, resulting in enhanced prices.

The process involved in starch manufacture is extremely simple, but in order to be financially successful the raw material must be cheap and the factory machinery both efficient and well run. This implies expensive management which can only be economically applied for large quantities of starch.

Among Indian raw materials which could possibly fulfil the requirements of the industry, is the sweet potato, (*Ipomoea batatas*,) which is cultivated widely in Bihar, yields well per acre at small cost, comes into the market at several different seasons and some varieties contain upwards of 20 per cent. starch. Experiments have therefore been commenced on the subject of starch manufacture generally and primarily from this material in particular. A very good quality of "farina" can be readily prepared from it.

X. Milk.

Detection of added water in milk. The value of the freezing point of milk as a means of detecting added water was referred to in my last annual report. It was there explained that the value of the test could only be given serious weight after determining the freezing point of a considerable number of milks of known purity, and if the variation were then found to be sufficiently small.

I took the opportunity when on tour to apply the test to a further number of milks at dairy farms, and although the variation of freezing point among milks of Indian cattle is greater than has been found elsewhere, there is no doubt that it forms a much more delicate test for added water than those hitherto employed. It is proposed to publish a note on the subject shortly.

XI. Programme of work for 1915-16.

Major subjects :—

1. Records of the amount and nature of drainage water from fallow land, and land bearing crops are maintained.

2. Experiments on possible improvements in the refining of saltpetre will be continued.

3. The relation between the transpiration of water by plants and the assimilation of plant material during the period of growth will be examined.

4. An examination of the proportion of starch in some of the Indian starch producing crops will be made and their possible utility from the manufacturing standpoint will be considered.

Minor subjects :—

None.

XII. Publications.

1. Indian Village Ashes as a Source of Crude Potash Salts, by J. Walter Leather. *The Indian Trade Journal, xxxviii, p. 132.*

REPORT OF THE IMPERIAL ECONOMIC BOTANISTS.

(A. HOWARD, C.I.E., M.A. AND GABRIELLE L. C. HOWARD, M.A.).

I. INTRODUCTION.

The Imperial Economic Botanist held charge of the section during the year under review. On February 10th, 1915, the Personal Assistant was promoted by the Secretary of State, on the recommendation of the Government of India, to the post of Second Imperial Economic Botanist.

The work of the staff continues to be satisfactory. The post of Fourth Assistant was filled by the appointment of Chowdhri Ram Dhan Singh, who was confirmed after twelve months' service as a probationer. The good work of the Second Assistant, Maulvi Abdur Rahman Khan, was rewarded during the year by a substantial increase in pay. At Quetta, Overseer Chandu Lall has made satisfactory progress.

Two advanced students, from Bombay and Bengal respectively, worked for a session in the section. The former then proceeded to England, having obtained a scholarship for three years for plant-breeding work; the latter has been recommended for trial in the Bengal Agricultural Department as a probationer.

II. INVESTIGATIONS AT PUSA.

Wheat. *Pusa 12.* In the last report, a detailed account was given of the successful trials by cultivators of Pusa 12 in the chief wheat-growing provinces of India and of the initial steps contemplated in the establishment, on a commercial scale, of an improved grade of white wheat. During the year under review, considerable progress has

been made in both these directions and important results have been obtained.

In connection with the trials of Pusa 12 by the ryots in the various wheat-growing areas, the results obtained in the United Provinces are perhaps the most important. The season in these provinces was not a very favourable one for wheat. The rains ceased early and, in many Districts, the crop had to be sown in too warm a seed-bed. The winter rains were late and although there was a marked improvement in February, this was speedily followed by long continued wet weather which brought on rust and seriously diminished the yield. Under these adverse conditions, Pusa 12 did well and stood out conspicuously from the country wheats. The general results are thus summed up by the Director of Agriculture in " United Provinces Agricultural Notes for March, 1915 " which appeared in the *Pioneer* of April 11th last.

" Pusa No. 12 wheat, of which a considerable area is now grown over different parts of the Provinces, has done well everywhere. It has shown itself relatively rust-resisting, and has given a good yield even in the worst affected districts. This feature has attracted particular attention in a year like the present, and there is little doubt about its rapid spread in future."

In the previous wheat year, 1913-14, a season of short moisture, Pusa 12 did much better than the country wheats as it was able to ripen a good crop with comparatively little moisture. Shortness of moisture during the growth period, the early cessation of the rains (leading to a warm seed-bed and subsequent liability of the seedlings to wither and to be destroyed by white ants) and long continued wet weather after the crop comes into ear (giving rise to serious attacks of rust) are the chief factors which limit the yield of wheat in the Gangetic alluvium. From the point of view of the testing of a new variety in this tract, the two seasons, 1913-14 and 1914-15, have been very favourable ones as, in both cases, adverse factors have been experienced. In both years, Pusa 12 has shown a

marked superiority over the local wheats and these facts must be regarded as of the greatest promise for the future of this variety.

During the year, the best yield of Pusa 12 so far reported was that obtained by Mr. Clarke at the new Sugarcane Experiment Station at Shahjahanpur, where over 500 maunds of seed were obtained from an area of 16½ acres, although a portion of this was badly lodged by rain and wind just after the crop came into ear. This outturn is over 30 maunds or 40 bushels an acre. Very good returns were also obtained on the private farms of the Taluqdars of Oudh as well as in other parts of the Provinces. The results clearly show that it is possible to produce in India wheats which combine both high yield and good quality when grown by the people themselves.

Progress has been made in the work relating to the shipment of Pusa 12 for trial by the Millers of the United Kingdom. This side of the work is being carried out in the Central Circle of the United Provinces with the co-operation of Mr. B. C. Burt, Deputy Director of Agriculture, who is working to replace the country wheats by Pusa 12 from certain centres near Cawnpore. The surplus will be bought up by Government and shipped by Messrs. Ralli Brothers who, with Mr. Humphries, have undertaken to bring this wheat to the notice of the Home Millers so that they may have an opportunity of getting first hand experience of its qualities and behaviour. In the District work, the Co-operative Credit movement has been utilized as well as Court of Wards' estates and large *zamindars*. In spite of the shortness of seed from Bihar and the disinclination of the ryots to sell their surplus produce, a beginning has been made during the present year and the first parcel was sent to London in June last. In 1916, it is hoped to send larger quantities and to organize the work in such a manner that certain of the local wheat markets will in time be able to supply pure Pusa 12 to the shippers. The work in the Central Circle of the United Provinces in attempting to replace a country crop by a

new variety of better quality is an important undertaking which, if successful, will be a distinct step in advance. Up to the present, what has been done has been to produce improved wheats and to test them under cultivators' conditions. The next stage is to replace the country crop by the new kind and, while this is in progress, to convince the Home Millers that India can produce much more valuable wheats than those now exported. Once a large area is completely replaced, the wheat trade can supply itself and fraudulent admixture with local wheat will be rendered difficult.

Besides Pusa 12, two other new wheats, No. 4 and No. 6, are proving useful in certain parts of India. Where the supply of soil moisture is limited and where the general conditions require a rapidly maturing wheat, Pusa 4 is meeting a long-felt want. This variety possesses strong straw, good grain and is also practically immune to yellow rust. In Bundelkhand, it is being successfully distributed to the cultivators by Mr. Burt. As a cover crop for Java indigo in Bihar, this variety is also likely to be of use. The kind, however, which appears to suit Bihar best as a single crop is No. 6, which for the last few years has done exceedingly well on the Belsund estate. It is practically immune to both the common rusts in Bihar and seems to thrive even under adverse conditions. With the spread of drainage in Bihar, it will be possible to extend the cultivation of wheat and to make sure of a fair crop even in unfavourable seasons.

In addition to the results obtained in India, the new Pusa wheats have been tried with success in other countries. In the Argentine, where the ordinary crop is often damaged by hot winds before harvest, Pusa 12 and Pusa 4 have given good results and a stock of seed is being worked up for distribution on the Government farms. Equally favourable reports have been obtained from Australia and the Sudan. It seems probable that, in addition to India, Pusa will prove of use as a wheat-breeding station for the warmer wheat-growing areas of the world.

Wheat-breeding. Considerable progress has been made during the year in still further improving Indian wheats in the direction of increased rust-resistance, better standing power and higher yield. The past year has been perhaps the worst for wheat so far experienced at Pusa. The root development was poor, due to the warmth of the sub-soil, and, after the crop came into ear, the wet weather was followed by an epidemic of rust. Notwithstanding these adverse conditions, a good many of the cultures were not affected by either of the three rust fungi which attack wheat in Bihar. These new wheats are now in the fifth generation and are practically fixed.

Tobacco. The demand for seed of the cigarette tobacco, Type 28, continues to increase and a large quantity was distributed during the year. It will be necessary to raise still larger quantities of this seed in future years to meet the ever increasing demand. The seed was cleaned and separated into two grades before issue by a special machine on the principle of a corn dresser. All light and poorly matured seeds are removed and the resulting seedlings are stronger and more robust than those raised from ordinary untreated seed. The tobacco seed is so minute that only those individuals which are heavy and well filled contain sufficient reserve material for producing rapidly-growing seedlings.

During the year, the practical results obtained in the cultivation and curing of tobacco were published as a bulletin. These have been referred to in previous reports and it is unnecessary to repeat them here. The experiments connected with improved methods of raising tobacco seedlings and with green-manuring for this crop are being continued.

Progress has been made during the year in tobacco breeding and in the study of the inheritance of characters in both *N. tabacum* and *N. rustica.*

Indigo. A considerable amount of progress was made in the indigo investigations which enabled definite recom-

mendations to be placed before the planting community. A study of the so-called wilt disease, which has been responsible for the great diminution of area under Java indigo in Bihar in recent years, led to the realization of the important part played by the root nodules in the general economy of the plant and also in the production of indican. This in turn made it possible to perceive the factors on which the yield of indigo depends and to work out improved methods of production both of indigo and of indigo seed.

Indigo wilt was found to be the last phase in a starvation process which always takes place in this crop when the work of the root nodules is seriously interrupted. Wilt may be produced in two quite different ways. In the first place, when indigo has been subjected to long continued wet weather, resulting in a waterlogged condition of the ground and in an insufficient supply of air for the roots and nodules, the plants cease to thrive, growth slows down and the characteristic unhealthy foliage associated with wilt is produced. Such plants die slowly without setting seed and when the wilted condition has been reached are found to have lost most of their nodules and feeding roots. In the second place, wilt is produced in healthy plants growing in soil where there is plenty of air and moisture, when the nodules are suddenly deprived of their food supply. If rapidly growing Java indigo, sown in August for seed, is cut down to the ground in October, most of the plants die and only a few make fresh growth. In the majority of cases, this new growth is wilted and such plants maintain themselves during the cold weather with the greatest difficulty. Examination of the roots, soon after the cutting back, shows that the nodules are in a moribund condition. These results enabled improved methods of cultivation and of seed-growing to be devised, which were immediately tried and found successful on the indigo estates themselves.

The secret of success in the cultivation and management of both Java and Sumatrana indigo has been found

to be efficient surface cultivation in the hot weather combined with drainage in the monsoon. The hot weather cultivation, for which suitable implements have been introduced into Bihar, enables the crop to obtain an ample air supply and also leads to the destruction of weeds and to a great saving in the cost of production. Surface drainage on the Pusa system, by preventing the flow of surplus rain water over the indigo fields, assists in maintaining the essential air supply to the roots and nodules and so tends to increase the growth and to prevent wilt. The adoption of these methods on the Dholi estate for the 1914 crop led to a record yield both of finished indigo and of *seeth*.

The discovery of the nature of the wilt disease also led to a method of growing the seed of Java indigo which is rapidly being taken up all over Bihar. Formerly, the old indigo crop was kept over the cold weather and seed was collected from these plants. This placed the planters at the mercy of the season as, in many cases, the crop became so weak from wilt that it produced only a small quantity of poor seed. At the same time, very large areas had to be set aside for seed which became very foul with weeds. The new method makes the planter independent of the season and leads to the certain production of well-grown seed from a comparatively small area which can easily be kept in a clean condition. For seed, Java indigo must be sown in early August in high-lying, well-drained fields which are in good condition. The plants must be well-cultivated and properly spaced so that they grow rapidly and come into flower towards the end of October. At this period, the weather is warm and dry, bees are abundant and all the conditions for pollination are present. This method was adopted on the Dholi estate for the 1915 harvest when a very fine crop of seed of over eleven maunds to the acre was obtained. The land was afterwards kept through the hot weather and yielded crops of leaf in the ordinary way.

The provision of a better cover crop for Java indigo has enabled several estates in Bihar to reduce the cost of

cultivation. A new variety of wheat, Pusa 4, has been introduced which can be grown with indigo on high lands. This wheat is a rapid grower, does not tiller much, has a strong straw and is provided with few leaves. On this account, the young indigo plants get a full supply of light and air and the two crops do very well together. It is hoped later on, when this new wheat spreads, to establish a grade for the Calcutta market.

Among the items of investigation now in progress with regard to indigo may be mentioned the selection work on Java and Sumatrana and the experiments devised to increase the efficiency of *seeth* as a manure. New varieties of Sumatrana and Java indigo are being tried this year on an estate scale and the results will be dealt with later. Evidence has been obtained that a part of the value of *seeth* in tobacco growing is its power of aerating the soil and of providing the soil organisms and the roots of the tobacco with an adequate supply of air. If this is confirmed, *seeth* can probably be made to go further by adding the proper proportion of broken tiles (*thikara*) to the soil.

The progress that has already been made in the indigo investigations indicates that the prospects of resuscitating the industry are very favourable. The competition of the synthetic product has, for the time, been removed, a period of high prices has set in which will be the means of establishing confidence and of putting the estates which are growing indigo into order. The value of the industry to Bihar agriculture is considerable. *Seeth* is an excellent manure and the part played by the Java plant in the rotation in aerating the subsoil is much greater than is commonly realized. Apart from all the other aspects of indigo growing, the industry is well worth saving from the point of view of the welfare of the people and of the maintenance of the fertility of the soil.

Gram. For some years, a botanical study of the varieties of gram, cultivated in India, has been in progress at Pusa and a good deal of work has been done on the general requirements of this crop as regards soil and culti-

vation. A considerable volume of results has been obtained which has now been arranged for publication. As in Java indigo, the well-being of the crop depends to a very large extent on the physical condition of the soil and on a copious supply of air to the nodules and roots. The results obtained, on different classes of soil in the Botanical area, explain both the present geographical distribution of gram in India as well as the dependence of the yield of seed on the season. The two chief climatic conditions which limit the yield are heavy rains, which produce surface crusts and deprive the roots of air, and damp weather at flowering time which interferes with pollination. Self-pollination is the rule in gram at Pusa but instances of natural crossing occasionally occur. Twenty-five types, differing widely in habit and yielding-power, have been isolated which are now being tested for yield under varying conditions. One interesting fact has already come out of these variety trials, namely, the union of high yield and good quality in the same variety. Type 9, grown at Pusa for the last four years on a large scale, on widely varying soils and in very different seasons, has given an average yield of just over twenty maunds per acre. This is the second highest average outturn, the best being that of twenty maunds thirty-three seers yielded by Type 18. Taking both yield and quality into consideration, however, and on the basis of the valuation of Messrs. Ralli Brothers, Type 9 gave the best return, an average of Rs. 78-11-0 per acre while the average produce of Type 18, the highest yielder, was worth only Rs. 61-4-0 per acre. This result is another illustration of the value of selection methods in improving Indian crops in the present condition of agriculture in this country. Had an attempt been made by hybridization methods to achieve such a union of yielding power and grain quality, the work entailed would have been arduous and long continued.

Fibres. In 1910, a study of the varieties of *patwa* (*Hibiscus cannabinus*) was completed at Pusa when it was observed that one of the kinds, Type 3, appeared to be much more suitable for cultivation than any of the others. In

the account of this work published in 1911 (*Mem. Dept. of Agr. in India, Botanical Series*, Vol. IV, No. 2), mention was made of a possible method of keeping cultures of this type pure by removing heterozygotes in the seedling stage. If this could be done in practice, the difficulties with regard to vicinism in the case of a crop in which a good deal of natural crossing takes place, would be surmounted. Since that time, Type 3 has been grown from unprotected seed and every year the plot has been rogued in the seedling stage and again before flowering commenced. In this way, all heterozygotes have been removed and the kind has been kept pure, notwithstanding the many opportunities of crossing which occurred with the other types grown in the Botanical area. A pure seed supply having been obtained and the method of production having stood the test of time, steps were taken to work out the best way of retting and to obtain expert opinion on the produce as compared with the fibre produced locally. By cutting the plant at the proper time and retting it in clean river water, a very fine sample of fibre was produced which was submitted for opinion and valuation to Messrs. Wigglesworth & Co., 82, Fenchurch Street, London, E.C., who valued it at £18 per ton compared with £8 from the locally produced fibre. Messrs. Wigglesworth stated that the sample of Type 3 was "of excellent growth, being 10 to 12 feet long, exceptionally light-coloured, correctly retted and thoroughly cleaned. Judging by the individual stalks, I should conclude that the yield of fibre must have been of quite exceptional weight. The fibre is pure from end to end and is free from root. It is also of good tensile strength and I have no hesitation in pronouncing it the best specimen of fibre from the *Hibiscus cannabinus* plant which has ever been submitted to me. This class of fibre could be sold in almost unlimited quantities."

Great stress was laid by Messrs. Wigglesworth in their report on correct and thorough retting and on the importance of this in connection with manufacture. Their valuation will serve to draw attention once more to the

great increase in value of fibre, such as Deccan and *sann* hemp, which would immediately be obtained if more care were taken in retting and in placing the product on the market in the most suitable form. All this has been pointed out many times before but the fact that a carefully retted sample from India should have made such a favourable impression on the brokers proves how low is the present standard of preparing fibre in this country for the European manufacturers.

Seed of Type 3 can now be obtained at Pusa and trials of this fibre on some of the estates in Bihar are being arranged.

The work on the inheritance of characters in *Hibiscus Sabdariffa* and on *sanai* (*Crotalaria juncea*), referred to in the last report, was continued during the year and considerable progress was made.

Oilseeds. For some time, a botanical study of the oilseeds of India has been in progress at Pusa and the results obtained in the case of two of these crops—safflower (*Carthamus tinctorius, L.*) and *rai* (*Brassica juncea*, H. f. & T.), —have been prepared for publication. During the coming year, it is hoped to continue the study of Indian linseed.

Safflower. Both as a source of oil and to some extent of colour, safflower is widely distributed over many parts of India. The crop has been under investigation at Pusa for six years during which period a fairly detailed botanical study has been completed. Form separation has been undertaken, the heterozygotes have been removed and twenty-four different types, covering a considerable morphological range, have been studied in pure culture. The pollination mechanism of the flowers has been investigated as well as the influence of moisture on setting. Self-pollination is the rule in this crop but a fairly large proportion of crossing also takes place. In 1914, when the types were grown next to next in lines, this was proved to be about sixteen per cent.

The distribution of the red colouring matter (carthamin) to the flowers of safflower was found to be complex, indi-

cating the existence of a number of different colour factors. Carthamin is absent altogether in some of the types while in others it is but feebly developed. Dr. Marsden of Madras, who carried out some dyeing tests with the various types, found that the best colour bearing variety was eight times better than the worst. In the percentage of oil in the seeds, the range in values is nothing like so great as in the case of the carthamin content of the faded flowers. With one exception, the percentage of crushed seeds extracted by ether varied from 20·77 to 30·19. Nineteen of the twenty-four types contained over one quarter of their weight of oil. Oil and carthamin content were not found to be antagonistic and in several types high oil and high colour occurred together.

Indian mustard (*rai*). The most interesting feature of this crop, when studied in pure culture, was found to be the extraordinary range in form. One hundred and two pure types were isolated which varied from thirty inches to nearly ten feet in height. Almost every conceivable intermediate form between these extremes was represented and so close was the resemblance that in many cases the types would only be distinguished by the massed habit.

Self-pollination was found to be the rule in *rai* but crossing, to the extent of about fourteen per cent., occurred when the types were grown next to next in lines. The pollination details were found to agree in the main with those previously described in other species of *Brassica*. A certain amount of evidence was obtained on the inheritance of characters in this crop which indicated the existence of numerous factors. Time will not admit of this aspect of the work being continued.

Both in safflower and in *rai*, the results obtained in this study point to the overwhelming importance of selection in the improvement of crops like these in which some crossing takes place and where the range of form is so great. Form separation, if conducted on a broad basis, would almost certainly lead to the isolation of any desired type which could be multiplied at once and distributed to

cultivators. Hybridization work, on the other hand, begun without exhausting the possibilities in selection, might easily prove to be unnecessary even if, after many years of work, it proved successful.

Soil ventilation and drainage. For some time the existence of an important limiting factor in crop production has been suspected in India, namely, the want of sufficient air for the soil organisms and roots of plants. A large number of observations on plant growth have been made at Pusa, at Quetta and in other parts of India which can be most easily explained by a want of proper aeration of the soil. All the evidence obtained, as well as the results of a number of experiments, have been consistent with this view. During the year, a preliminary statement of the case was put forward in Bulletin 52 in which some of the work in progress was outlined. The volume of the gases in the soil is naturally bound up with the amount of water present and this in turn opens up many questions with regard to irrigation and to the saving of water in crop production. The practical applications of the views put forward are many and obvious. In some cases, they have already been translated into practice. The regulation of the air supply of the soil in the case of Java indigo has given important results which have been indicated above under that crop (p. 35). There seems little doubt that the future of the indigo industry in Bihar depends on the copious aeration of the soil in which this crop is grown. In the case of green-manuring in India, soil ventilation appears to be one of the chief factors on which success depends, while in tobacco cultivation in Bihar there is reason to believe that the cost of manuring can be materially reduced if means of permanently aerating the soil are adopted.

Perhaps the most important direction in which the air supply of the soil can be increased in Bihar is by means of surface drainage. A method has been worked out at Pusa and is now in successful operation on several of the estates in Bihar. This consists in dividing up the area

to be drained into areas, of from five to ten acres in extent, by means of a set of trenches, so devised that the surplus rain water is got rid of and, at the same time, soil erosion is prevented. On the Dholi estate, some remarkable results were obtained during the year. In one case, a large area, which previously gave little or no return on account of waterlogging, was so transformed in a single year by surface drainage that it was let out to ryots for chillies at a rent of ninety rupees a bigha, to the manifest advantage both of the cultivators and of the estate. In another case, a portion of the *zerat* which had previously been rendered very infertile by scour was let to tobacco growers, for the first time, at a rent of one hundred and forty rupees a bigha. Similar results have been obtained on other estates and there is little doubt that this improvement, the capital cost of which is not more than two rupees a bigha, will spread rapidly in Bihar. To obtain the best results, however, it will be necessary to study the rivers in North Bihar in detail and to draw up proper drainage maps and working plans. This aspect of the subject has been dealt with in Bulletin 53. The full development of drainage in Bihar is now beyond the means of the Botanical Section and can only be realized by the employment of engineers. Enough has been done, however, to show how much the production of Tirhoot can be improved by increasing the air supply in the soil by surface drainage. Bihar is now the waterlogged garden of India. Drainage would double its production.

III. The Development of the Agriculture of Baluchistan.

The preliminary work connected with the establishment of the fruit and agricultural Experiment Station at Quetta has been described in detail in previous reports. During the past year, the final details connected with the irrigation arrangements and storage of water were completed. In addition, a good many results of practical value were obtained.

Dry farming. The saving of irrigation water in wheat growing in India is one of the problems which is certain to receive, in the future, an increasing amount of attention on the part of the Agricultural Department. Any extension of the area irrigated by the water now available means increased revenue to Government and greater openings for the surplus agricultural population. At the same time, the less water applied per unit area, the smaller is the danger of waterlogging and of interference with the general healthiness of the locality. A study of the wheat crop under irrigation in many parts of India indicates that too much water is often given and that satisfactory crops can be grown with much less than is now applied. This is particularly the case in the Quetta valley, where good crops of wheat are only grown on heavily manured land which receives at least six and sometimes more waterings. These frequent waterings are considered essential, as the crop has to ripen under a rapidly increasing temperature and in a wind-swept area where the humidity is low. The circumstances at Quetta appeared to be exceedingly favourable for experiments in water saving. These have been completed during the year at the new Experiment Station and the results are of more than local interest. It has been found that very satisfactory crops of wheat can be grown on a single irrigation. This is applied to the land during September after which it is cultivated and sown in October. A good germination is obtained and there is ample moisture in the sub-soil for the development of a deep root system during the autumn and winter. After each fall of winter rain or snow, the soil moisture is conserved by harrowing with the Canadian lever harrow and, by the time the crop begins to shoot in March, there is a good deal of moisture left in the ground. There is also an ample supply of air for the roots and crops grown in this way ripen much earlier and better than the ordinary irrigated crop. The wheat thus escapes a good deal of the heat and dry winds of May and June. The yield obtained on an area of 2·85 acres of unmanured land at

Quetta on one irrigation was 47 maunds 24 seers or 16 maunds and 28 seers to the acre—an outturn which compares well with the average of 13½ maunds per acre grown on similar land with six or seven waterings.[1]

In the above experiment, the conditions were not very favourable. The rain which fell during the life of the crop was badly distributed. There was little rain in January and February while the late falls in April formed surface crusts which could not be broken up on account of the height of the crop. A yield of over 16½ maunds to the acre with one irrigation, compared with the average of 13½ maunds with at least six waterings, clearly proves that at the present time large quantities of valuable water are being wasted in growing wheat in the Quetta valley. There is little doubt that the same thing is taking place in the Punjab where the duty of irrigation water could be increased considerably.

Fodder crops. One of the great needs in Baluchistan agriculture at the present time is some crop by means of which the porosity and moisture holding capacity of the soil can be increased. Leguminous fodder crops, which can also be used as green manure, offer a possible solution of this problem and accordingly some attention has been paid to this matter.

Shaftal. The most promising fodder crop suitable for green-manuring purposes so far found at Quetta is Persian clover or *shaftal* (*Trifolium resupinatum*). When sown

[1] The results of numerous crop-cutting experiments in the District are summed up in the *Quetta Pishin Gazetteer* (p. 102) as follows :—

" In Quetta, 75 experiments were made in 1895-96 and the outturn of wheat per acre in irrigated land was found to be 15½ maunds, the highest being 17½ maunds in the Kasi Circle and the lowest 14 maunds in the Baleli and Durrani Circles. Mr. J. A. Crawford, in commenting on the items, remarked that the results of crop experiments were notoriously apt to be high. Further experiments, made in 1903-04, however, showed still higher returns, the average in irrigated and manured land being 24 maunds, 6 seers, and in irrigated land not manured 13½ maunds. In other parts, the average has been found to be as under :—

	Pishin Mds.	Shorarud Mds.	Chaman Mds.
Land irrigated and manured . .	25	15	15
Irrigated land not manured . .	16	12	10
Dry land	5	5	3

in August, under a thin cover crop of maize or *juar*, Persian clover, if properly managed, gives on good land three cuts of green fodder, weighing about 60,000lb. per acre, before the end of the following May. In addition, the last cut can either be ploughed in as a green manure or else kept for seed. The yield, however, is greatly reduced both by overwatering or by failure to cut the crop in time. The beneficial effects on the soil following *shaftal* are very great particularly on the tilth and general fertility. This is now being recognized and a considerable amount of seed was distributed in 1914.

Before *shaftal* can be taken up on the large scale by *zamindars*, some method of disposing of the crop to advantage must be found. The green crop is a safe fodder for horses and cattle and particularly for dairy cows, provided care is taken to mix it with sufficient *bhusa*. Lucerne, however, is undoubtedly a more popular green fodder and is now grown on a large scale round Quetta. Green forage, however, can only be produced in the summer and during the winter there is a large demand for dried fodder. This is at present met by lucerne, dried in the country fashion, without fermentation. The harsh and brittle nature of this food is obvious and it has the further disadvantage that it cannot be made into pressed bales. During 1914, experiments were made in the drying and baling of *shaftal*. By carefully adjusting the moisture it was found possible to make *shaftal* into good hay, to obtain the proper fermentation in the stack and to press it into bales. This can only be done in the exceedingly dry climate of Quetta by conducting the operation in all its stages in such a manner that the *shaftal* never becomes air dry. Once it is completely dried out, it is so brittle that it cannot be handled and baling is out of the question. The final product was indistinguishable from good English clover hay. Over a hundred bales were prepared in 1914 and tried as a fodder by one of the Heavy Batteries at Quetta during the winter. The Commandant reported that it was an excellent fodder, much superior to

dried lucerne. A much larger number of bales has been prepared during the present year which will be offered to various units of the Quetta Division for trial next winter. The military advantage of a pressed fodder, equal to English clover hay, is obvious in India while the extended cultivation of *shaftal* in the Quetta valley would be certain to increase production and thus augment the present supplies.

Lucerne. The methods of growing lucerne in Baluchistan are of some interest. The land is first of all manured before sowing and every year the crop is top dressed with more manure during the winter. There is no cultivation at any stage and water is applied by flooding the surface. The frequent manuring evidently promotes aeration of the surface soil and so removes some of the disadvantages attending the method of watering. Evidence has been obtained that surface cultivation of the lucerne after irrigation by means of the spring tine cultivator is likely to take the place of the manurial dressings. An experiment has been started to compare the yield of green crop under the two methods of treatment.

Some trials were made in 1914 to prepare and bale real lucerne hay in place of the dried unfermented local product. While it is possible to make good lucerne hay in the dry atmosphere at Quetta, the process is not easy on account of the fact that the moisture is so readily lost before fermentation takes place. *Shaftal* is much more easily made into hay at Quetta than lucerne.

Other fodder crops. Besides *shaftal,* several other new fodder crops have been tried. Ordinary English red clover grows at Quetta and withstands the hot weather of July but the rate of growth is not great and this fodder is not likely to compete with *shaftal* and lucerne. Italian rye grass behaves much like red clover but the difficulties connected with the germination of the seed under local conditions are likely to prevent this crop ever being taken up. A mixture of rye grass and *shaftal* was found to be unsuitable for hay as the rye grass dries much too quickly. Ber-

seem (*Trifolium alexandrinum*), which does so well in Sind, will grow at Quetta but the weight of crop is small and it is not likely to be of use in the valley. A Mediterranean fodder crop known as sulla (*Hedysarum coronarium*) was tried in 1914 at the suggestion of Mr. A. C. Dobbs, Assistant to the Agricultural Adviser to the Government of India, but it proved a complete failure and was largely killed by the cold.

Fruit Investigations. *Improved fruit boxes.* The supply of improved fruit boxes for the use of dealers and the public was continued during the year. The demand is steadily increasing both on the part of the Indian dealers and also from the general public. About 2,500 boxes were sold during the year and as these are distributed all over India they ought in time to help to raise the present low standard of fruit packing in the country.

Some improvements have been made in the design of the packages for the five seer parcel rate. The use of chip compartments is being given up while the boxes are being made more thief-proof. In place of the separate chip compartments, a collapsible cardboard fitting has been used. This folds flat and is imported ready for use. Peach boxes entirely of cardboard were put on the market for the first time in 1914. The whole of the outside of the box consists of a single piece of cardboard and the boxes can be set up very rapidly. The separate compartments are of collapsible cardboard. With these boxes, thefts in transit are quite impossible. The supply was sold off at once and, judging by the demand, cardboard fruit boxes are likely to become exceedingly popular in India. They can be used several times over if necessary.

For consignments over five seers in weight, fruit packing cases must be made of wood and, to travel well for long distances under Indian conditions, it is essential that there should be a system of small units like the two pound punnets which are now being adopted at Quetta. There is one difficulty, however, which must be overcome, namely,

a reliable source of box boards at a reasonable price. Originally, these box boards were imported from Glasgow but the rise of wages and freights has increased the cost considerably. At the present time, the conditions of trade with Great Britain have still further increased prices. A large amount of time has been spent in trying to discover an indigenous source of suitable wood but without much success. India apparently has not yet reached the stage when cheap boxes are required in numbers. Most of the trade is still in the gunny bag and wicker basket stage. It is possible that after the war, the necessary boards for fruit packing boxes can be best obtained direct from Norway.

Supply of fruit trees. A beginning was made in 1913 in the supply of fruit trees to the public. Only good varieties which suit local conditions are propagated and care is taken to shape the trees in the nursery during the summer before they are distributed. The demand for this stock has rapidly increased and during the past year between four and five thousand trees were sold. No trees are given away and proper prices are charged. This tends to check waste and also ensures that most of the trees distributed are properly cared for afterwards.

Experience shows that the further development of fruit growing in Baluchistan is to a great extent a question of suitable varieties propagated on suitable stocks. A large collection of the best local and imported kinds is being made and added to every year. The experiments on the influence of the different stocks are already yielding most interesting results. The mahaleb, mariana, mirabolan and almond are likely to prove exceedingly useful as stocks in the Quetta valley. For the present, the first three have to be imported from France. With proper care, however, the percentage of deaths is very small and it might easily prove cheaper to import stocks in bulk than to raise a local supply. As the new varieties come into bearing and as the various experiments with stocks develop, it will be possible to improve the nursery work still further. Before the Experiment Station was started, no records of varieties had

been kept at Quetta so that all this work has had to be done over again from the very beginning.

IV. Programme and Publications.

Programme of work for 1915-16. *Plant breeding and plant improvement.* Work will be continued on the following crops, on the lines indicated in the annual reports and in the publications of the section—wheat, tobacco, gram, fibre plants, indigo, oil-seeds and fruit.

Publications. Some progress was made during the last twelve months in the publication of results but the arrears have not yet been overtaken.

The following papers were published during the year :—

1. The influence of the environment on the milling and baking qualities of wheat in India. No. 3. The experiments of 1911-12 (with H. M. Leake). *Mem. Dept. of Agr. in India (Botanical Series)*, Vol. VI, No. 8, 1914.
2. Pusa 12. *Agr. Jour. of India*, Vol. X, Part 1, 1915.
3. The improvement of tobacco cultivation in Bihar. *Bulletin 50, Agricultural Research Institute, Pusa*, 1915.
4. First report on the improvement of indigo in Bihar. *Bulletin 51, Agricultural Research Institute, Pusa*, 1915.
5. Soil Ventilation. *Bulletin 52, Agricultural Research Institute, Pusa*, 1915.
6. Soil Erosion and surface drainage. *Bulletin 53, Agricultural Research Institute, Pusa*, 1915.
7. Second report on the improvement of indigo in Bihar. *Agr. Jour. of India*, Vol. X, Part 2, 1915. Reprinted as *Bulletin 54, Agricultural Research Institute, Pusa*, 1915.
8. Report on Agricultural Botany for 1913-14, for the Board of Scientific Advice.

REPORT OF THE IMPERIAL MYCOLOGIST.

(F. J. F. SHAW, B.Sc.)

I. CHARGE AND ESTABLISHMENT.

The Officiating Imperial Mycologist remained in charge of the section throughout the year. There were no changes in the establishment. The Officiating Imperial Mycologist was on tour for 77 days during the year and the First Assistant for 75 days; the "ufra" disease in Eastern Bengal, the wilt of chillies at Peshawar and the recent outbreak of "black thread" on rubber plantations in Burma absorbed most of this time. The number of mycological investigations in progress at some distance from Pusa, for Provincial Departments of Agriculture and Forest and Opium Departments, is increasing every year. All the staff have worked well.

II. TRAINING.

Babu Jamini Bhusan Sinha, Fieldman in Mycology, Sabour, was under training from December 5th, 1914. Mr. S. L. Ajrekar, B.A., Assistant Professor of Mycology, Poona College, worked in the laboratory from 28th October to 5th November 1914. Mr. B. L. Gupta, B.Sc., of the Reid Christian College, Lucknow, completed a course in Mycology, which he commenced on 11th May 1914, and left Pusa on 8th July 1914.

III. DISEASES OF PLANTS.

The investigation of the diseases of crops, the collection and identification of Indian fungi and giving assistance to cultivators and officers of the Department formed the principal work of the section.

(1) Paddy. The work on "ufra," the nature of which was described in the last annual report, was continued and experiments were conducted at Comilla and at Pusa with a view to the discovery of some remedial measure. Owing to a deficiency of water in the experimental area at Comilla

this work did not give any conclusive results. The experiment is being repeated this year with additional precautions.

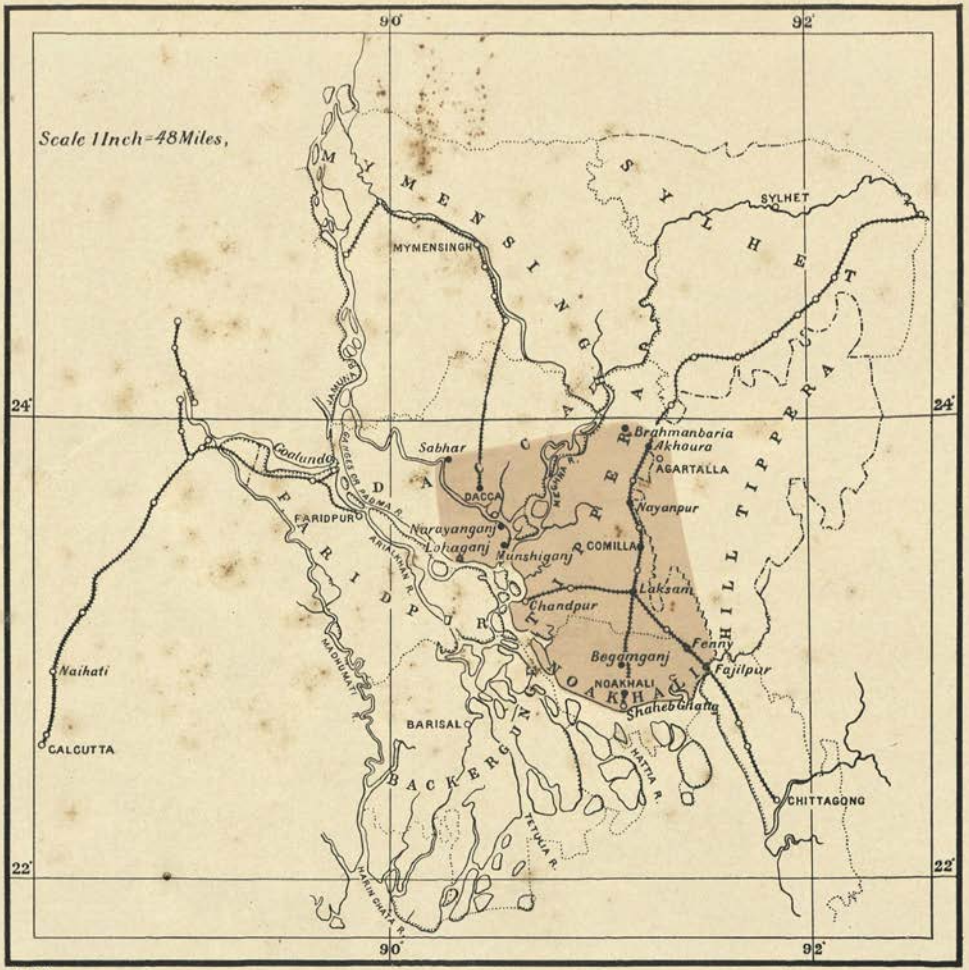
Working with small plots at Pusa it was found that the disease could lie dormant in the soil and infect a new crop. Cutting the diseased crop and burning it *in situ*, with a little kerosine, prevented the infection of a succeeding crop. It is unsafe, however, to generalise from a small experiment such as this, for it is possible to subject a small area to a much more thorough burning than would be practicable on a field scale.

The infected area in Eastern Bengal appears to be much the same as last year (see map) and the disease has been again reported in the vicinity of Ranchi, in Bihar and Orissa, where it is said to occur on transplanted paddy and not upon the early broadcast.

A diseased condition of the paddy crop in Balasore and on the Government Farm at Bankipore was investigated but "ufra" was not found; at Balasore drought appeared to be the cause of the trouble but at Bankipore the condition was said by local officers to be that known as "chatra," however, no trace of a parasite could be found.

The "gwa-bo" disease, which is the cause of extensive damage in Burma, was investigated without any very definite result. In some areas about 50 per cent. of the disease appears to be due to *Sclerotium Oryzæ* Catt. (vide *Memoirs of the Department of Agriculture in India, Botanical Series*, Vol. VI, No. 2, July, 1913) but it is almost certain that the diseased condition is the result of the combination of a number of adverse factors and is not due to the attack of any single parasite. In particular some insects appear to be responsible for a large amount of the disease.

(2) Tobacco. Field experiments with "tokra" of tobacco were commenced and yielded some results of scientific interest. *Orobanche cernua* Loefl. and *Orobanche indica* Buch. both occur on tobacco but *O. cernua* is much the more serious parasite of tobacco and solanaceous crops generally, while *O. indica* is a source of heavy damage to



K.D.Das.

MAP SHOWING DISTRIBUTION OF *UFRA*.

ENGRAVED & PRINTED BY THE CALCUTTA PHOTOTYPE CO.

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Cruciferæ (*e.g.*, mustard, cabbage). A good crop of tobacco was raised on a field which had been under cabbages in the previous season and which was known to be infected with *O. indica.* Further experiments to test the effect of different chemical manures on the incidence of "tokra" are in progress.

(3) Rubber (Hevea). At the request of the Director of Agriculture, Burma, the section undertook the investigation of a disease of *Hevea* called "black thread" in Lower Burma. The disease is characterized by the appearance of longitudinal black lines in the naked tissue immediately above the tapping cut. These black lines mark areas of disintegration, stretching through the cambium into the wood, and as tapping proceeds they follow the fresh cut down the stem. The flow of latex becomes decreased, but, the most serious aspect of the disease is the failure of an infected tree to regenerate the bark over the tapped area.

Microscopic examination of the black cracks has, up to the present, failed to demonstrate the presence of any fungus parasite, but in the bark immediately adjoining the infected area hyphæ of a fungus often occurred. This fungus was identified as *Phytophthora* the cause of the "canker" of Hevea. At the moment of writing the investigation has not been carried further but experiments are in progress.[1]

(4) Sal tree (Shorea robusta). At the request of the Bengal Forest Department the section undertook the investigation of a disease in the sál forests of the Duars, said to be due to a fungus parasite. In the Buxa Division a considerable number of sál trees can be seen in a dead and dying condition. When dead the trees are left standing bare and leafless and in dying trees the foliage is scanty and there are obvious indications of a decrease in vigour of growth. In all the dead and dying trees which were examined there were indications of a fungus attack in the roots. If the main root of an unhealthy tree is laid bare

[1] Infections with pure cultures of this *Phytophthora* have since been successful in producing this disease on healthy trees.

to a depth of about 3 feet and the outer corky tissues are cut away with a knife it is found that the phloem has been destroyed leaving nothing but the bast fibres; in the disintegrated tissue between the strands of fibres white rhizomorphs occur and a fungus mycelium is everywhere common. In dead and badly affected trees this condition is found to extend up the trunk sometimes as much as 2 feet above the soil. In such cases a fructification of a bracket fungus (probably *Fomes*) is often found on the stem. In every case examined in which this fructification was present the phloem showed the diseased condition described above. Thus while all unhealthy trees show a diseased condition of the phloem, with the presence of a mycelium with rhizomorphs, the most advanced cases of disease also bear a sporophore. From field observations therefore there is a strong presumption that the disease is due to the attack of a basidiomycete of the genus *Fomes;* the fact that this fungus is one of a group which is responsible for most diseases of timber strengthens the evidence and moreover the presence of rhizomorphs in the diseased phloem is what would be expected in association with a *Fomes* fructification on the exterior of the trunk.

The fungus has been obtained in pure culture and will be tested by inoculations. While it is not unlikely that the fungus is the direct source of damage it will probably be found that the conditions under which the sál trees are living are such as favour the presence of a fungal parasite and decrease the vitality of the sál tree. When the factors which are necessary for the fungus to gain entrance into a healthy sál tree are known it may be possible to control the disease by altering the hygienic conditions under which the trees live and thus lessening the chances of a successful infection. It is improbable that it will be possible to apply any remedial measures in dense jungle such as occurs in Buxa; treatment might, however, be possible in the case of plantations.

(5) Rhizoctonia. Work on this fungus was continued and the results are published as a memoir of the Depart-

ment. The species *R. Napi* West. was found to be a dangerous parasite of mustard and gram. This fungus is incapable of active growth at temperatures above 29°C.—a circumstance which limits its depredations in India. A fertile stage was discovered and found to be identical with the well known *Botrytis cinerea* Pers., which was described as a disease of mustard by Frank some forty years ago. As a result of this it is considered that *R. Napi* is not a true member of the genus *Rhizoctonia*, which should be restricted to those species with a fertile stage in the genera *Corticium or Hypochnus*. The species *R. destruens* Tass. was found to be the cause of serious disease of betel vine and potato in Lower Bengal, Bihar and parts of Bombay. In the latter province it also occurred on suran, lucerne and groundnut. There were some indications that the fungus had a perfect stage in the genera *Corticium* or *Hypochnus* but no satisfactory proof could be obtained. Experiments suggested that corrosive sublimate was a more reliable fungicide against *Rhizoctonia* than formalin or copper sulphate.

In continuation of the research into the blight of opium poppy experiments were conducted with a view to discovering whether *Rhizoctonia* or *Peronospora* was the chief cause of this disease. Poppy was grown at Pusa from seed supplied by the Opium Department and the resulting crop became infected with *P. arborescens*. This fungus was also very plentiful on poppy in the vicinity of Ghazipur, but at Patiali *Rhizoctonia*, and not *Peronospora*, was found. The matter cannot be regarded as definitely settled but it is probable that *Rhizoctonia* is only a serious parasite of poppy when conditions such as poor soil or defective drainage are inimical to the growth of the crop.

(6) Anthracnose. The investigation into anthracnose of betel vine did not yield any results of practical importance. There is no doubt, however, that the perfect stage of this *Colletotrichum* is an ascomycete belonging to the genus *Glomerella*. Attempts to secure successful inoculations failed and our knowledge of this disease is therefore not

in so good a position as it appeared to be last year. The well known anthracnose of chillies appears to be the cause of a good deal of trouble in the chilli growing districts of Burma and some form of treatment may be necessary.

IV. Miscellaneous.

A certain amount of work was done on the fungi of Pusa soil. The chief interest of this preliminary investigation was the striking similarity between the fungus flora of an Indian soil and that which occurs in Europe. The species isolated in Pusa were—

Cunninghamella elegans Lendn.
Aspergillus fumigatus Fres.
Aspergillus niger v. Tiegh. *Sterigmatocystis nigra* v. Tiegh.
Rhizoctonia Napi West.

of which the first three are all known in the soil in Europe.

The fungus which causes " red rot " of sugarcane was found to be parasitic upon juar under laboratory conditions but so far is not known to cause serious damage to this crop in the field. A rot of bananas was examined by the First Assistant and found to be due to a parasitic *Fusarium*. A preliminary account has been published in the *Agricultural Journal of India*, it appears that the disease is distinct from the well known Panama disease of bananas. The results of some observations on potato blight in India have been published as a memoir of the Department, the chief point of practical importance is the fact that the fungus cannot survive in the heat of the plains. Mr. Dastur has continued his work on *Phytophthora* with the study of some forms parasitic on *Vinca*, it is hoped to publish results shortly.

Some preliminary work on the disease of chillies at Peshawar indicated that the disease was of the type known as " wilt." Inoculations with a fungus isolated from diseased plants were not successful and this year the incidence of the disease is much less. Treatment of oat smut

with formalin on certain estates in Bihar was, as usual, completely successful.

V. Systematic Work.

The additions to the herbarium amounted to 155 specimens during the year. Collections of fungi for naming were received from, and duplicates were issued, if required, to the Mycological Officers of Provincial Departments. The publication of systematic mycology by the Imperial Mycologist has been largely done in collaboration with Herrn H. and P. Sydow of Berlin; the outbreak of war with Germany has of course prevented this collaboration being continued and will hinder the publication of the series "Fungi Indiae Orientalis."

VI. Programme of work for 1915-16.

(1) *Research work.* All new fungus diseases of crops will be the subject of investigation as they come to the notice of the section but the following diseases will receive special attention and will constitute main lines of investigation :—

(1) Ufra of paddy.
(2) Smut of sugarcane.
(3) Wilt of cotton, sesamum, gram and chilli.
(4) Black thread disease of rubber.
(5) Blight of opium poppy.
(6) Root rot of sál tree.

Research work will also be continued upon phanerogamic parasites and fungi of the soil.

(2) *Systematic work.* The care of the herbarium will continue to form an important part of the work. Minor papers on systematic mycology will probably be published.

(3) *Training.* This will be continued on the lines indicated in the prospectus. Short courses may be given as necessary.

(4) Routine work of advising on plant diseases will be continued and assistance will be given as usual to Provin-

cial Departments of Agriculture, the Forest Department, Planters' Association and general public.

VII. Publications.

(1) Butler, E. J. . The cultivation of Rice in Spain and the Recent International Rice Congress at Valencia. *Agri., Jour., India, IX, Pt.* 4, Oct. 1914.

(2) Dastur, J. F. . The Potato Blight in India. *Mem. Dept. of Agri., India, Bot. Ser.* VII, No. 3, April, 1915.

(3) Shaw, F. J. F. . Report on Mycology, 1913-14, for the Board of Scientific Advice.

REPORT OF THE IMPERIAL ENTOMOLOGIST.

(T. BAINBRIGGE FLETCHER, F.E.S., F.Z.S.)

I. CHARGE AND ESTABLISHMENT.

The Imperial Entomologist held charge of the section throughout the year. Mr. A. J. Grove, Supernumerary Entomologist, whose services had been lent to the Punjab Department of Agriculture since 27th January 1914 for the investigation of insect damage to stored wheat, left the Department on 27th April 1915 on termination of a six months' extension of his probationary period. Mr. G. R. Dutt was on privilege leave from 5th October to 4th November 1914 and Mr. D. Nowroji from 5th to 31st October 1914. The services of G. D. Ojha, Fieldman, were lent to the Department of Agriculture, Central Provinces, for six months from 5th April 1915 in connection with work on *Nephotettix*.

II. TOURS.

The Imperial Entomologist was on tour in Burma from 26th July to 6th October, in the Punjab and North-West Frontier Province from 9th to 25th October, in the Central Provinces from 9th to 18th April, in the North-West Frontier Province from 13th May to 1st June and also visited Calcutta to work at the Indian Museum from 14th to 23rd June, a total absence from headquarters of 130 days.

Mr. C. S. Misra, First Assistant, visited the Central Provinces in July 1914 to investigate cane-borers and again in February 1915 to inquire into an outbreak of *Nephotettix* in rice areas for which purpose he also toured in the Central Provinces and Orissa from 5th to 21st June 1915. He also visited the Karauli and Benares States in February and May respectively to advise regarding development of the lac industry.

Mr. C. C. Ghosh visited the Sepaya Farm in September 1914 to examine the indigo planted in connection with *Psylla* experiments.

Mr. G. R. Dutt toured in Southern India from 29th March to 17th May 1915 to collect information and specimens of insects, especially Hymenoptera.

Mr. M. N. De, Sericultural Assistant, visited Muktesar in October 1914 to distribute directly from there the univoltine mulberry silkworm eggs which had been placed in cold storage during the hot weather. He also went to Calcutta in November 1914 to assist in displaying the silk exhibits sent from Pusa for the Exhibition of Indigenous Products as compared with Enemy Goods.

The Fieldmen were sent on tour as occasion required throughout the year in connection with outbreaks of pests.

III. Training.

No students completed the course in Entomology during the year but two were received from the Punjab in June 1915. G. D. Ojha and Harihar Prasad, Entomological Fieldmen at Pusa, were also given some special training. The short courses in Lac and Sericulture only attracted four students, a number much below the average; the Banswara State, Central India, sent one man for the Lac course in June 1915, one student completed a course in Eri and Mulberry Silk and two Sericultural students remained under training at the close of the year. The reduction in numbers of the short-course students seems to be directly due to the publication of popular Bulletins on the culture of lac and silk, although it may be noted that mere book-instruction cannot take the place of practical work.

IV. Crop Pest and other investigations.

1. Cotton Pests. Experiments, which are still in progress, were made to test the relative immunity of different varieties of cotton to attacks of bollworm (*Earias*). A large number of sowings were made of numerous cottons from the United Provinces, the Punjab, the Central Provinces and

Bombay in combination with other malvaceous plants, and weekly counts made of the bollworm infestation. The bollworms found were also examined for the presence of parasites, which were recorded, bred out and liberated in the experimental area. So far as noted hitherto the infestation of *Earias* by *Rhogas* is remarkably small (less than 5 per cent.) even under the most favourable conditions, and it would appear that the influence of *Rhogas* has been greatly exaggerated. In May and June 1915, in compliance with a request from the Director of Agriculture, all the *Rhogas* pupæ obtained were sent to the Punjab to assist in establishing the parasite there.

Some work has also been done on the life-history of *Machærota planitiæ*, whose nymph lives in a curious calcareous tube on stems of cotton. The presence of this insect frequently stunts the growth of the young shoots and it may occur in sufficient numbers to do considerable damage.

2. Sugarcane Borers. Borers in sugarcane (both new sowings and ratoon canes), maize, *juar*, and rice stems and stubble have been collected and the insects bred out for further study and comparison. Affected canes were also received from the North-West Frontier Province and the insects reared. In March 1915 fresh sowings of cane were made with maize as a trap-crop and, as soon as the presence of borers became apparent, these were collected, counted and reared for further study to ascertain whether the borers in cane and maize are really distinct; this experiment was not concluded at the end of the year.

3. Garden Pests. The study of pests of fruit-trees, flowers and vegetables was continued and illustrations made for a Bulletin on Fruit-pests.

4. Parasites of Scale-insects. With a view to sending parasites of *Aspidiotus aurantii* to Italy, a study was begun of the parasites of this scale-insect which occurs commonly at Pusa on *Citrus* spp. and roses, but very few parasites could be obtained.

A large amount of Lecaniinæ material was collected with a view to finding any parasites which might be of use in the control of *Coccus viridis* (*Lecanium viride*) in the coffee districts of Southern India, but it was found that the majority of the local *Lecaniinæ* were free from Chalcid parasites; only those scales found on *Ficus religiosa* and *Ricinus communis* were parasitized to any extent.

5. Parasites of Aleurodids. As noted in last year's report, attempts have been made to procure a parasitized colony of *Aleurodes citri* for export to Florida. The parasite which attacks *A. citri* on *Jasminum* is the same as the one which attacks *A. ricini* on castor, and castor plants were therefore grown and infected but unfortunately became heavily infested with *Tetranychus bimaculatus* and later on by a leaf-fungus and the plants therefore had to be rejected. A very similar parasite attacks another *Aleurodes* on *Ficus* and trials with this are also being made.

6. Economic Aleurodidæ. Life-histories of *Aleurodes citri*, *A. bergi*, and *A. ricini* were completed.

7. Pyrilla aberrans. The complete life-history of *Pyrilla aberrans* was worked out during the year and repeated thrice to check the period of a life-cycle. Chalcid, Dryinid and Stylopid parasites were also reared, some of these being new. It may be noted that three species of *Pyrilla* (*P. aberrans*, *P. perpusilla* and *P. pusana*) are found on sugarcane at Pusa, all formerly confused under the first name.

8. Nephotettix bipunctatus. Much time was given to the outbreak of *Nephotettix bipunctatus*, the rice leaf-hopper (locally called "Maho") in the Central Provinces. This insect was first reported as a pest from the Sakti State in the Bilaspur District of the Central Provinces. A Fieldman was sent to make investigations on the pest and to try measures suggested from Pusa. These measures consisted of (1) bagging with large field bag-nets, (2) bagging with hand-nets, (3) brushing over the infested fields with a rope dragged over the plants, (4) oiling the infested fields with kerosine and then dragging a rope across so as to

submerge the plants temporarily, (5) spraying with contact insecticides, and (6) putting up lantern traps in the affected fields. Of these, it was found that the last was the most efficacious and that most readily adopted by the cultivators.

A leaflet on this pest in English and Hindi was written and issued by the Department of Agriculture, Central Provinces, and widely circulated amongst the cultivators of the affected districts. It has also been translated into Uriya and issued by the District Board in Balasore, where an outbreak of *Nephotettix* also occurred. A trained Fieldman was lent to the Central Provinces to carry on continuous observations of the pest and to advise adoption of remedial measures in the Raipur and Bilaspur districts which were severely infested last year.

9. Life-histories. In the insectary were reared some two hundred insects which had not been reared previously. Considerable attention has been paid to various insects (mostly Coleoptera) found at and just below soil-level and about sixty different beetles have been reared and their breeding-places, earlier stages, food and habits noted. Many of these beetles are predaceous and are therefore beneficial by destroying plant-feeding crop-pests; amongst such may be noted an unidentified Carabid predaceous on a Cydnid bug, a species of *Chlœnius* predaceous both in the larval and adult stage on caterpillars of *Utetheisa pulchella*, and several Elaterid beetles. Of these last a single grub of *Agrypnus* sp. ate more than 200 Scarabœid grubs in the course of about three months, and another Elaterid larva was found to exercise a considerable check on Tenebrionid grubs feeding at the roots of gram and other crops.

A point, which has been observed with regard to some common insects (*Laspeyresia, Chilo, Chloridea*) reared for observation of exact cycles of their life-history, is that out of the same batch of larvæ, feeding and commencing to hibernate at the same time, some hibernate and emerge as adults whilst others hibernate during the cold weather,

then æstivate during the hot, dry season and emerge at irregular intervals thereafter as late as July or August. From the practical point of view of control this is of some importance, as measures taken on the first appearance of the insects after hibernation may be rendered abortive, or will at least require to be supplemented, in view of these later emergences. An observation of this kind, apparently trivial in itself, emphasizes the fact that an intimate knowledge of the habits of the insects concerned must be the first step towards their control.

Crocidolomia binotalis is a cold weather pest of Cruciferæ. Unsuccessful attempts were made to find out how it passes through the rest of the year.

Zonabris pustulata is an extremely common black and red Blister beetle whose life-history is yet unknown. Eggs were obtained in November 1914 and hibernated in the soil, hatching at the end of the cold weather, but all attempts to get the young larvæ to feed on eggmasses of various grasshoppers proved unsuccessful, and the grubs could not be reared. Dr. Roepke, of the Experimental Station at Salatiga in Java, has recently informed me that he found larvæ of this species feeding on eggmasses of *Cyrtacanthacris;* it is probable that this beetle has a similar habit in India.

Another failure was encountered in further attempts to obtain the life-history of *Anthia sexguttata*, a giant Carabid which feeds in the adult state on practically any insects it is able to catch.

A Bruchid beetle (*Bruchus affinis*) was observed to lay eggs extensively on pea-pods at Pusa in January and February, so that the peas may be infected in the field before being stored. These seeds have been treated and stored in various ways to ascertain the extent of damage and how it can best be checked.

An unidentified Dermestid beetle in stored wheat has been found to complete its transformation in from one to two years.

Further observations have been made on the life-history of *Odoiporus longicollis*, a weevil which bores in plantain stems, and the life of the adult beetles has been found to extend to a period of up to two years.

With reference to the campaign against *Agrotis ypsilon* at Mokameh it was not known how this insect passes through the hot weather and rainy season in the plains of India. Large numbers were therefore obtained in March and it has been found that, under conditions in the Insectary, continuous broods have been obtained, which suggests that it may breed somewhere in the vicinity of the areas attacked in September-December.

The status of *Tenebroides mauritanicus* as a grain-pest having been doubtful, this was ascertained by experiments, by which it was found that this beetle and its larvæ certainly can and do eat wheat and rice grains, preferring wheat to rice. The adult beetle preys upon the adult rice weevil, *Calandra oryzæ*, so that in grain affected by *C. oryzæ* the presence of these beetles is beneficial as, when present in sufficiently large numbers they will ultimately rid the grain of the weevils although they themselves will eat a small proportion of the grains; but the resultant loss will be less than if the weevils bred unchecked. Further experiments will be undertaken with this insect.

Batocera rubus, a longicorn beetle commonly boring in Fig, Mango, etc., has been reared from the egg and the complete life-cycle observed to occupy a year.

Balaninus c-album has been traced throughout the year, though not reared from eggs. The life-cycle occupies a year.

Complete life-cycles have been observed of *Plotheia celtis*, *Porthesia xanthorrhœa*, *Perigea capensis*, *Spodoptera mauritia*, *Liogryllus bimaculatus*, *Terias hecabe*, *Hypolimnas bolina*, *Euplœa core*, *Junonia orithiya*, *Huphina nerissa*, *Papilio polytes* and *Deilephila nerii* and further observations have been made on numerous other insects.

Fruit-flies have been reared in large numbers—in thousands in some cases—from various fruits in order to procure parasites and to ascertain the proportion parasitized. In the case of *Bactrocera cucurbitæ* the results have been disappointing as parasites were very few and it is perhaps owing to this fact that this fruit-fly does so much damage to cucurbitaceous vegetables. Only in one lot of fruits of *Momordica charantia* were the maggots found to be attacked by a Braconid parasite to the extent of about 16 per cent., and even this parasite was not found to be present throughout the year. The peach-flies (*Bactrocera zonata*) showed an insignificant percentage of parasitism and the parasitic grubs were observed to remain in a resting condition throughout the remainder of the year.

Carpomyia vesuviana was reared from fruits of Ber (*Zizyphus jujuba*) and was found to be extensively parasitized. Attempts will be made, at the request of the Royal School of Agriculture at Portici, to introduce this parasite into Italy, whence this fruit-fly was originally described its specific name being derived from the fact that the original specimens were taken on the slopes of Mount Vesuvius. The flies remain in the pupal state for some time, from about February to June or later, but the parasites emerge about March and probably have an alternative host.

In order to test the effect of poisoned sprays on fruit-flies long series of flies reared in the insectary were fed with a solution composed of Lead Arsenate $2\frac{1}{2}$ to 5 oz., *gur* $2\frac{1}{2}$ lb. and water 4 gallons, and it was found that a strength of 3 to 5 oz. of Lead Arsenate kills the flies in about 36 hours.

A Braconid parasite of *Diacrisia obliqua* was bred for a generation to note its life-cycle and rate of increase and some work was also done on an Ichneumonid parasite of *Spodoptera mauritia*.

Odontotermes assmuthi, the largest of the five Termites known to occur at Pusa, has been under observation for the last four years. From the emergence of adults which

took place in July 1914 several observation nests were established in the Insectary and new colonies were successfully started and soldiers and workers reared. This is the first time, so far as I am aware, that any species of the true earth-dwelling *Termitidæ* has been reared from the egg to any adult stage under observation, although some of the woodliving *Protermitidæ* and *Mesotermitidæ* have been reared in Europe. Further colonies are now being reared.

10. Insecticides. Experiments in the preservation of wood against attacks of Termites (White Ants, so called) were continued, the species of Termite experimented with being *Microtermes obesi* (*anandi*), which is apparently a common species throughout the plains of India. "Powellized" wood, supplied by the agents for testing, has failed almost wholly within four years. "Sideroleum," tested as a preservative of wood against Termites, has also failed; further tests will be made of it. Testing of "Microlineum" as a preservative has been started.

Creosote was tried to make sugarcane setts immune to Termites without interfering with germination, but these experiments failed.

11. Stored grain pests. A series experiments on the preservation of rice, wheat and pulses against insects under stored conditions has been commenced on a small scale. The methods found most effective will be tested on a larger scale.

12. Silk. One student completed a short course in Eri and Mulberry and two were undergoing training at the close of the year. The univoltine mulberry silkworm eggs, which were sent to Shillong and Muktesar for rearing in March, gave satisfactory results but those sent to Muktesar for rearing in October did not hatch properly as the natural temperature of the place from July to October was not sufficiently low. Our attempts to establish a superior stable multivoltine hybrid race, which would not degenerate, were continued. Mulberry silkworm eggs were supplied to 171 rearers and eri eggs to 144 applicants and

mulberry and castor seeds to 20 applicants. One Fieldman and a rearer were sent to Jeolikote, Kumaon, for rearing eri worms in April and May as it is difficult to procure a fresh stock of eggs for distribution in June and July. Thirty-one pounds of eri cocoons were supplied to Messrs. Inagaki & Co. of Kyoto for testing in the mills of Japan. Difficulty was experienced by the rearers in disposing of eri cocoons in small lots. Silk exhibits were sent to Exhibitions held at Muzafferpur, Monghyr, Pudukottai, Mysore and to Calcutta, Madras and Cawnpur in connection with the Exhibition of Indian as contrasted with German and Austrian goods. The Secretary of the Mysore Dasara Exhibition awarded a silver medal for the exhibits. Eighteen silk pieces were loaned to the Director General of Commercial Intelligence, Calcutta, for the Exhibition of Indian as contrasted with Enemy Goods. Eight sets of silk exhibits were sent to the Superintendent, Central Seed-store, Bengal, Sibpur. His Highness the Maharaja of Darbhanga took a keen interest in all the operations of the industry during His Highness' visit to the Institute. Instruction was given by correspondence in silk-dyeing, bleaching, silkworm rearing, reeling and spinning. Rupees 937 worth of silk, manufactured at Pusa, was sold.

13. Lac. During the past year emergences of larvæ took place on the 28th September 1914 and 10th June 1915 and in the two seasons 120 Ber trees were inoculated. Broodlac was supplied to 7 persons. Specimens of lac from two new food-plants, which were not hitherto recorded, were received from the Honorary Secretary, Agri-Horticultural Society of India, Calcutta, and the Economic Botanist, Lal Bagh, Bangalore. Parcels for sending in lac specimens were sent only to such Forest Officers from whose Division or Range the series of specimens was not complete. Unfortunately serious gaps occurred in the past and these have not been filled up as yet.

Five tubs containing Kusumb (*Schleichera trijuga*) plants were inoculated and despatched to Mr. N. Fujii,

Hozan, Formosa, through the Consul-General for Japan, Calcutta.

During the year the services of Mr. C. S. Misra, First Assistant, were requisitioned by the Karauli Durbar to report on the progress of lac cultivation started by the Forest Officer of the Durbar who was trained in Lac work at Pusa. A separate report embodying his suggestions was submitted to the Durbar through the Political Agent Bharatpore.

In May 1915 Mr. Mistra's services were requisitioned by the Benares State to advise on the possibility of extension of Lac cultivation in the Chakia district of the State. A separate report on this embodying his suggestions has been sent to His Highness the Maharajah of Benares through the Political Agent to His Honour the Lieutenant-Governor of the United Provinces, Benares.

A student was deputed by the Banswara State in Central India to undergo a month's training in Lac culture. The student joined the course on 7th June 1915 and went back to the State on the 3rd July 1915.

Copies of the Lac Bulletin in English and Hindi were sent or sold to numerous inquirers.

14. Bees. During the year experiments with the Indian Bee (*Apis indica*) were continued, special attention being paid to the three principal defects of this bee in the plains, *viz.*, (1) deserting the hive in autumn, (2) inability to defend the hive against Wax Moth, this being one of the causes which lead to desertion, and (3) frequent swarming.

The results obtained this year go to show that the bees can be prevented from deserting the hive and a little care prevents the Wax Moth, a well-made hive being of great help in this direction. A little care bestowed on these bees leads to an increase of the population in the colony but stimulates swarming. Efforts made at checking swarming were not successful. It appears that the old principle of inducing swarming early in the season so as to have a number of colonies from which to take surplus honey in the honey season, will be more suitable to these bees than the

new principle of checking swarming and having larger surpluses from strong and populous colonies. The work will be continued. A Bulletin on Bee-keeping was issued at the close of the year.

V. Illustrations.

Illustrations were prepared, to the extent of artistic assistance available, of the insects studied during the year. Coloured plates, showing the complete life-history, were prepared during the year of the following insects:—*Utetheisa pulchella*,* *Odoiporus longicollis*,* *Atractomorpha crenulata*, *Oxycarenus lætus*, *Plusia orichalcea*, *Perigea capensis*, *Etiella zinckenecila*, *Glyphodes indica* and *Chilo simplex*,* of which those marked * are printed and available. Numerous line drawings have also been made and will be utilized as occasion arises. The issue of coloured plates and lantern slides has been continued.

VI. Miscellaneous.

Correspondence. A total of 103 parcels of specimens, mostly of crop-pests, was received during the year for identification and advice, whilst 1,119 letters were received and 1,374 issued, but these numbers are exclusive of a large amount of routine correspondence.

VII. Insect Survey.

Steady progress has been made in additions to and arrangement of the collection. The whole of the collection of *Hymenoptera* has been rearranged in one series, so that all the information on any species or group is now available in one place. The same is being done with the Coleoptera, and other groups will be taken up as time and staff permit. The following collections were sent to specialists in the groups named and our thanks are due to them for the help afforded:—Chalcididæ to Dr. L. O. Howard, Formicidæ to Mr. W. M. Wheeler, Stylopidæ to Mr. Dwight Pierce, Dryinidæ to Mr. J. C. Crawford, Rhynchota to Mr. W. L. Distant, Coccidæ to Mr. E. Ernest Green, Noctuidæ and

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Pyralidæ to Sir George Hampson, Rutelidæ, Cetoniadæ and Dynastidæ to Mr. G. J. Arrow, Carabidæ to Mr. Andrewes, Histeridæ to Mr. George Lewis, Curculionidæ (part) to Mr. G. A. K. Marshall, Lucanidæ to Mr. F. H. Gravely, Microlepidoptera to Mr. E. Meyrick, Trypaneidæ to Professor M. Bezzi and their parasites to Professor Silvestri, and various Diptera to Mr. E. Brunetti.

Our thanks are due to His Excellency Lord Carmichael for a small named collection of moths from Darjiling.

Numerous sendings of specimens of insects have been identified for correspondents as far as possible.

Collections of flies, bugs, lice, ticks and other animals of interest as disease-carriers, made during the year at Pusa and whilst on tour, were transferred to the Imperial Pathological Entomologist.

VIII. Entomological Conference.

A meeting of the Entomological staff both of Pusa and the Provinces, was held at Pusa from 2nd to 8th February 1915. Similar meetings have been held previously, but not since 1909, and have hitherto been confined purely to the Agricultural Department. Opportunity was taken of the present occasion to extend the scope of the meeting to include others engaged in similar entomological work, and the Forest Zoologist, the Entomologist in the Indian Museum, and the Entomologist to the Indian Tea Association were also invited and attended and gave us the benefit of their experiences with various insects, which were of mutual interest. Besides these, Mr. E. Ballard, Government Entomologist in Madras, came from Coimbatore and Mr. E. J. Woodhouse, Economic Botanist, Bihar and Orissa, attended part of the meeting, whilst the Central Provinces and Bihar and Orissa each sent both their Entomological Assistants, and one came also from each of the following Provinces and States, *viz.*, Madras, Bombay, United Provinces, Assam, Baroda and Travancore.

An abstract of crop-pests had been prepared beforehand and specimens of each got out in show-cases in order that

there might be no doubt regarding the identity of any species under discussion. The list was worked through systematically and each insect discussed as regards its distribution, crops attacked, damage done, control, etc. The gaps in our knowledge respecting distribution especially, which revealed themselves during the meeting, were emphasized by the absence of the Entomological Assistants from Burma, Bengal, the Punjab and North-West Frontier Province, but in spite of this the meeting proved most valuable, especially to the Provincial Staffs, who are thereby helped to keep in touch with our work done at Pusa and that done in Provinces other than their own. It is hoped that similar meetings may be held regularly in the future.

IX. Programme of work for 1915-16.

This will follow generally on the lines of work of the current year and will include general investigations of crop-pests and especially of the pests of rice, sugarcane and cotton, of fruit-trees and of stored grain.

A commencement has been made of collection of information for a general book on the crop-pests of India and progress in this will be continued, as also in the publication of information regarding life-histories of pests and coloured plates, of which a large number are now ready for printing. Work and experiments in Silk, Lac and Bee-keeping will be continued, and new Insecticides and insecticidal methods tested as occasion arises. Advice and assistance will be given as far as possible to Provincial Departments and to all inquirers on entomological subjects.

X. Publications.

The following publications have been actually published during the year under review :—

Books.

Some South Indian Insects, by T. Bainbrigge Fletcher. (Madras Government Press, Imperial 8vo., pages xxii + 565, 50 Plates and 440 text-figures.)

Bulletins.

No. 28. The Cultivation of Lac (Hindi edition), by C. S. Misra.

No. 39. Instructions for rearing Mulberry Silkworms (Bengali edition), by M. N. De.

No. 44. How to Improve Silk Reeling in Bengal, by M. N. De.

No. 46. Bee-keeping, by C. C. Ghosh.

No. 48. First Report on the experiments carried out at Pusa to improve the Mulberry Silk Industry, compiled by M. N. De.

Leaflets.

Maho (*Nephotettix bipunctatus*), by C. S. Misra (published by the Agricultural Department of the Central Provinces in English and Hindi and by the Balasore District Board in Uriya).

Practical Instructions for the Kollegal Mulberry Silkworm Rearers, by T. Bainbrigge Fletcher. (*Madras Dept. of Agri., Leaflet* No. I of 1914.)

Some General Methods of Controlling attacks by Insect Pests; Agricultural Methods; Mechanical Methods, by T. Bainbrigge Fletcher. (*Madras Dept. of Agri., Leaflets* III and IV of 1914.)

Miscellaneous.

Note on Tiger-Beetles from Coorg, by T. Bainbrigge Fletcher. (*Journal of the Bombay Nat. Hist. Soc.*, XXIII, 379.)

Report on Agricultural Entomology for 1913-14 for the Board of Scientific Advice for India, by T. Bainbrigge Fletcher.

REPORT OF THE IMPERIAL PATHOLOGICAL ENTOMOLOGIST.

(F. M. HOWLETT, B.A., F.E.S.)

I. ADMINISTRATION.

I was in charge of the section for the year, save for the period July, August, and September 1914, when I was absent on privilege leave and Hill recess. Mr. P. G. Patel was absent on privilege leave for 29 days and Mr. H. N. Sharma for one month and 20 days.

II. EDUCATIONAL.

No educational work was done. Mrs. Kilby and Mr. Awati worked in the laboratory for some time, the former at the reflexes of *Cimex* (*Clinocoris*), and the latter at the taxonomics of *Muscidae*.

III. RESEARCH.

There have been three main lines of enquiry :—

(1) A thorough investigation of the flies and other insects which breed in decaying or septic animal matter, including those that infest wounds and sores in domestic animals and man. Veterinary officers are being circularized for specimens of maggots, and the Pusa species have been under close observation for the last nine months. I have endeavoured to combine with the life-history observations an enquiry into the "chemotactic" reactions of the insects and of the parasites which evidently share them, but the chemical problems involved are such as require the assistance of a skilled biological chemist, who is unfortunately not available. The practical importance of an enquiry into these reactions is considerable, as a knowledge

of them would certainly simplify preventive and antiseptic measures.

(2) Energetic relations of insects: their consumption and economy of chemical energy under varying conditions. Mr. S. K. Sen is obtaining data for this investigation during my absence, in the form of food, oxygen, and water curves for the whole life-history of various insects. I hope subsequently to correlate this work with enzyme-investigations of the type recently carried out by Mr. Barnes at Lyallpur. Results of practical importance may or may not be obtained.

(3) The pure chemical substances responsible for the "chemotactic" reactions of the males of three species of fruit-fly have now been definitely and certainly ascertained. They are methyl-eugenol and iso-eugenol. Similar reactions in the case of a small Oscinid are produced by Isovaleric aldehyde. Analogous but not precisely similar cases are under observation.

The immediate practical value of this work is almost negligible; its ultimate value may be large, since it indicates the practical possibility of entirely new methods of insect-control. It is far and away the most important result yet achieved by the section.

IV. Miscellaneous.

(*a*) **Lice.** The lice of sheep and goats were investigated. A lime-sulphur spray or wash, followed by a spray of weak vinegar, was found to give excellent results. Internal administrations are being experimented with. On human lice the effect of extremely small quantities of mercury compounds was found to be very marked, though the way in which they act is obscure.

(*b*) **Bugs.** An attempt was made to elucidate the nature of the "biting-reflex" in the bed-bug. The enquiry proved difficult, but there were indications that the ventral

sense-organ was of importance; the work will be resumed at a later date.

(*c*) **Ticks.** *Ornithodorus savignyi*, a possible disease-carrier, is under observation.

(*d*) **Mosquitos.** A *Taeniorhynchus* and *Culex gelidus* have had their life-histories determined. Both are extremely troublesome to cattle, and *C. gelidus* breeds normally or very frequently in cow's urine.

The breeding-places of mosquitos in Pusa were carefully mapped in March, and some time later the Director gave facilities for an anti-mosquito campaign on "control-breeding" lines. This has been successfully carried on and I hope that my absence on leave may have no appreciable effect on the success of an experiment which opened auspiciously.

With a view to determining the influence of local waters on mosquito-breeding, experiments were made on the effect of equimolecular salt solutions on the larvæ. The results were of interest as indicating that an unexpectedly high percentage of lime in water is to some species distinctly beneficial.

(*e*) **Fruit flies.** The Ber fly, *Carpomyia vesuviana*, and its parasites were under observation for the year, and the life-history of *Dacus longistylus* was worked out. An attempt to check a very severe infestation of peaches by *D. zonatus* at Lahore failed completely, the attack having gone too far to save the crop. Spraying operations must be started as soon as peaches are just on the point of becoming ripe.

(*f*) **Other Diptera.** Rice in the Balasore district was seriously affected by *Cecidomyia oryzæ* and other insects. I investigated the part played by Cecidomyia; but found that the greater damage was being done by non-dipterous insects, mainly the Rice Hopper, and Mr. Fletcher thereupon took over the work. The life-history of three horse-flies (*Tabanidæ*) has been worked out, as also that of the very

curious Diopsid fly *Sphyracephala hearseyana*, though the habits of the adult are still obscure. The early stages of acalyptrate muscoids breeding in mushrooms have been obtained, but it is not known how these species spend the dry and hot part of the year.

V. Collaboration.

The usual amount of identification work was carried on; the Indian Museum was supplied with a considerable number of specimens to assist in the compilation of the "Fauna of India."

I interviewed the Director of Fisheries, Bengal, with reference to larvicidal fish in connection with control-breeding schemes.

In connection with the Kathgodam Surra work, a "pre-rains" survey of the area has been made for bloodsucking flies; this will be correlated with a similar survey made during the actual Surra season. I inspected the area in company with Mr. Shilston.

Arrangements have been made to assist Mr. Ballard in a chemical investigation of the sexual reactions of *Amsacta*.

I attended the 2nd Science Congress at Madras, and was pleased to note the increasing strength and authority of the organization, and the generally high quality of the papers read.

VI. Programme of work for 1915-16.

The three lines of enquiry mentioned under the heading "Research" in the above report will be continued. In the event of my going on leave my assistants will carry on Nos. (1) and (2) until my return. Sanction has been requested for the publication of a book as projected in last year's programme.

REPORT OF THE IMPERIAL AGRICULTURAL BACTERIOLOGIST.

(C. M. HUTCHINSON, B.A.)

I. ADMINISTRATION AND TOURS.

Charge. I held charge of this section during the whole year.

Establishment. Mr. J. H. Walton, the Supernumerary Agricultural Bacteriologist, was relieved of his duties to join his post in the Military Department on the 4th June 1915.

Mr. N. V. Joshi, the First Assistant, was on privilege leave for two months and 19 days with effect from 5th October 1914 and Mr. K. S. Vishwanatham acted for him.

Mr. Hardayal Singh, Assistant, was on privilege leave for one month and 12 days with effect from 19th August 1914.

Messrs. A. N. Bose and Hardayal Singh, assistants, were confirmed on the 26th May 1915 in their respective posts owing to the transfer of Mr. N. C. Basu to Bengal.

Tours. The following tours were made by me during the year 1914-15 :—

1. September 1914. To Calcutta to consult with the Excise Commissioner of Bengal, Bihar and Orissa and Assam on the subject of Bákhar and to investigate local conditions of rice beer distillation.
2. October 1914. To Shillong on Hill Recess.
3. November 1914. To Calcutta to interview Scientific officers of the Indian Tea Association and to inspect the Bengal Distillery Co.'s distillery at Konnagar.
4. March 1915. To Motipur and Peeprah Factory to arrange for carrying out manurial experiments with green manures.

II. Training.

Mr. Barkat Ali, Assistant to the Agricultural Chemist to the Government of Punjab, who was under training in this laboratory from 12th August 1912 to 13th August 1914, during the latter part of his training carried out an investigation on the bacteriological aspects of "Reh" soils from the Punjab and submitted a full and detailed report on this subject referred to below.

Mr. D. V. Bal, Assistant to the Agricultural Chemist, Central Provinces, was under training from 20th August 1914. Mr. Bal applied the method of biological analysis to samples of soils from Sind and carried out experiments in connection with the investigation of the action of bacteria upon nutrient matter in the soil and the occurrence of toxins in soils. He also isolated *Ps. campestris* from a specimen of diseased cabbage sent from Poona and from others locally obtained.

Mr. A. K. Bose, Assistant Chemist to the Indian Tea Association, Calcutta, worked in this laboratory from 13th February 1915. Mr. Bose was instructed in the method of biological analysis of soils and carried out experiments therewith on samples of soil from the Tea Districts as referred to in this report.

III. Soil Bacteriology.

Bacterio-toxins in soils. The work on bacterio-toxins in soils was continued and carried a stage further; it was found that the inhibition of nitrification occurring in soils under water-logged or semi-anaerobic conditions was not due merely to lack of the oxygen required for formation of the completely oxidized product, but to the action of toxins resulting from the activity of certain classes of bacteria which rapidly multiply under these conditions. That this toxic action was not due either to ammonia or carbon dioxide in excess was shown by the inhibitory action of water extracts of the toxic soil upon nitrification in normally aerated soil, and more conclusively by that of certain bacteria isolated from such soils, notably of one bacillus

(*Bacillus X*) the toxic action of which was found to be sufficient to interfere with the growth and activity of all other soil bacteria brought in contact with it or with its separated toxin in culture.

It was found that such toxins result from the decomposition of organic nitrogen compounds by bacterial action under semi-anaerobic conditions, and further proof that the inhibition of nitrification is not due merely to shortage of oxygen was afforded by the observation that, with the same air supply as was sufficient for complete nitrification of ammonium sulphate in soil, nitrification of oilcake containing the same amount of nitrogen was completely inhibited, nor did it commence when complete aeration was provided, until after the lapse of a considerable period (generally about two weeks although this varied with different soils) when the toxins formed had had time to become destroyed by oxidation, after which normal nitrification ensued. It was found in actual practice in the field that germination in a soil which had been water-logged was interfered with, and that the ensuing crop was consequently poor, nor was this remedied by application of nitrate of soda, although the use of superphosphate was successful. Laboratory experiments showed that rapid reduction of nitrate takes place in water-logged soil, a large proportion of nitrite being formed, and it seems probable that the toxins produced during the water-logged period would not only affect the germination and the growth of the seedlings but that the character of the soil complex resulting from the semi-anaerobic conditions which obtained at that time would be such as not only to interfere with nitrification but to promote reduction for just so long as this abnormal character persisted. The character of the soil complex and that of the decomposition products of organic matter resulting from its action must vary with alterations in moisture and oxygen content of the soil itself, and it is probable that the altered character may persist for some time after the special conditions which gave rise to it have disappeared. This point is under experimental

observation. It was found in the laboratory that superphosphate had a neutralizing action upon the toxicity to bacteria of extracts of certain soils and this was traced to the free acid; this result, however, was not sufficiently conclusive to allow of its use as a convincing explanation of the favourable action of superphosphate upon waterlogged soils, although this theory is supported by Meggitt's work in Assam, but will require further experimental investigation.

Ammonification proceeded at the normal rate in soil under semi-anaerobic conditions and was apparently not interfered with by the bacterio-toxins produced although the activity of such ammonifiers as *B. mycoides* is actually lowered by the presence of *Bacillus X.*; this latter organism does not appear to be universally present in soils; no concentration of ammonia above that in the aerated control was found nor was this gas given off by the anaerobic soil. The action of carbon dioxide in excess was eliminated by absorption with potash, as well as by the use of the soil extract as mentioned above.

A special experiment was made to test the action of the carbon dioxide formed in soil by bacterial action upon nitrification in that soil; under partially anaerobic conditions absorption of the carbon dioxide produced no effect upon nitrification in soil, either of oilcake or of ammonium sulphate; in this experiment, the observation was repeated that complete nitrification of ammonium sulphate took place under semi-anaerobic conditions in which no nitrification of oilcake occurred.

It appears therefore that in soils in which aeration is incomplete, as a consequence either of want of proper cultivation or of drainage, the decomposition of organic matter by such bacteria as thrive under these conditions will result in the production of toxins inhibitory of nitrification. It has also been shown that these toxins are destroyed by exposure to air and can be removed in water solution, so that the ordinary operations of tillage and drainage can prevent their accumulation.

Work with seedlings (wheat, oats, rice, indigo, maize, *dhaincha*, *jowar*), has shown that in high concentration, such as occurs in water-logged soils containing much organic matter, these toxins may directly affect growing plants especially seedlings, but this is an exceptional condition, whereas it appears probable that in normal fully aerated soils the toxins resulting from the ordinary metabolic activity of soil bacteria are oxidized at about the same rate as they are produced and no accumulation takes place. A very slight interference with the oxygen supply to the soil, however, will turn the scale in favour of accumulation of toxins and in consequence upset the natural equilibrium existing in the soil complex between the toxin-sensitive nitrifying organisms on the one hand and the apparently less easily affected reducing organisms on the other, thus resulting in indirect injury to the crop by interference with the supply of nitrogen as nitrate. In soil which has been flooded during the monsoon the toxins formed may persist long enough to seriously prejudice the growth of seedlings if planted too soon; such soil should be given as long a period of aeration as is possible before planting.

In order to ascertain the conditions under which such bacterio-toxins are produced in soils a great deal of work was carried out in isolating and determining the specific functions of soil bacteria, but the proper development of this line of enquiry would necessitate collaboration with a chemical specialist. The possible bacterial origin of the various organic compounds of a toxic nature which have been isolated from soils by such workers as Schreiner, Shorey, Skinner, Reid and others would be one of the problems involved. It was found that salts of some of the heavy metals such as copper had a decided influence in neutralizing the toxic action towards seedlings of extracts of soils kept under anaerobic conditions; precipitation of the copper as sulphide was prevented by the addition of potassium cyanide, these salts being present in very small quantities; (0·025—0·03 per cent. $CuSO_4$). It appears

probable that the discrepancies recorded between the observations of some workers upon the stimulating effect of such salts upon nitrification may be explained by reference to the fact that the cases in which contradictory results were reported were not comparable owing to the use of organic nitrogenous matter, from which toxins could have arisen, in one series, and ammonium sulphate in another.

An interesting case occurred in the field at Pusa in which the use of copper sulphate as a precautionary measure against attack by wire worms resulted in a large increase on the treated plot as compared with an untreated control although both were free from attack by wire worm.

It was found in the case of seedling maize and *jowar* grown in soil or sand and watered with extracts of soil made toxic by keeping the latter under semi-anaerobic conditions that the residual contents of the seed were attacked by bacteria which had multiplied as a consequence of the prevalence of such conditions and had been transferred with the toxic extracts; the result of this attack was the production of toxic putrefactive bodies in immediate contact with the seedling resulting in its death; this did not occur in presence of copper sulphate. Mr. Milligan, Imperial Agriculturist, who drew my attention to the abovementioned field result with copper sulphate, has pointed out the significance of this observation in connection with this case, and the importance of its bearing upon the vital question of successfully bringing a field crop through the initial stages of germination and growth especially in heavy soils. Experiments are being carried out to test the value of antiseptics in relation to the early stages of plant growth under varying soil conditions from this point of view.

The toxic action of nitrites upon growing plants was demonstrated both under sterile and ordinary conditions in water cultures.

Nitrification. Numerous experiments on nitrification in soils and solutions were carried out and much valuable information on the subject obtained. This was especially the case in connection with biological analysis of soils from

various parts of the country, carried out for the most part by Assistants of Provincial Agricultural Chemists undergoing training in this section. Mr. Barkat Ali, Assistant to the Agricultural Chemist to the Government of Punjab, made a valuable biological analysis of Reh Soils from that province showing that although such bacterial activities as are essential to nitrification are practically non-existent in Reh Soils, this condition is completely altered by washing out the excess of salt. Mr. D. V. Bal, Assistant to the Agricultural Chemist, Central Provinces, tested the nitrifying power and capacity of certain soils from Sind which had undergone differential treatment in the field; this was found to vary considerably as a consequence of treatment. Interesting differences in comparative immunity shown by the nitrifiers in these soils to the inhibitory effect of partial anaerobic conditions as compared with the nitrifying agents in Pusa soil were observed, nor was the addition of lime beneficial in this respect. Nitrification in tea soils from different districts was studied by Mr. A. K. Bose, Assistant to the Scientific Officer to the Indian Tea Association; here very marked differences in nitrifying power between different soils, were found with varying results from the application of lime, and varying optima for water. Further experience with the method of biological analysis of soils has shown its value in elucidating soil problems and has made it possible to reduce it to a simple set of concurrent experiments.

The observed influence of toxins upon nitrification has been referred to above.

Nitrate formation in field plots under different crops has been under observation; grass has been found entirely to prevent accumulation of nitrate in the soil in which it is growing; this would have some bearing upon the action of grasses upon fruit trees, as the absence of nitrates must mean either that nitrification is inhibited or that the grasses take up the nitrate as rapidly as it is formed, or that in grassed-soil reduction takes place at least as rapidly as oxidation.

The effect of various trees upon nitrification due to the fall of their leaves upon the ground was studied and considerable differences were observed.

The optimum amount of organic matter as oilcake containing 5 per cent. nitrogen for nitrification in Pusa soil was found to be about 1 per cent. of soil weight. At a concentration of 2 per cent. ammonia formation was so rapid as to result not only in inhibition of nitrification but in loss of nitrogen as ammonia gas; the free ammonia also brought organic matter into solution and made it necessary to abandon the use of the tintometer for estimation of nitrates and to use the aluminium reduction method, which was found more convenient and reliable for this particular purpose than the zinc-copper couple. Indications were obtained that the prejudicial effect of organic matter upon nitrification is in many cases due to the rapid multiplication of toxin-producing bacteria consequent on its presence.

The effect of temperature on nitrification in Pusa soil was tested, the optimum being found to be near 35° C.; no nitrate was formed at 40° C., nor did nitrification take place in soil which had been kept at 40° C., when its temperature was afterwards reduced to 30° C.; further work on this point is being carried out to determine the cause of this apparent lowering of the thermal death point.

A series of experiments was carried out to determine if possible for what reasons on adding as solids such bacterial food stuffs as oilcake or sugars, to a live soil, the evolution of carbon dioxide resulting from bacterial action should rise in rate for a few days but fall again rapidly to a minimum long before exhaustion of the food supplied could be called upon to account for such diminution in activity. Reasons were found for thinking that this result, invariably obtained when solid nutrients were added to soil, was due in part to auto-intoxication by the soil bacteria, and in part to the purely physical facts of the case, depending upon the ratio between the superficies and the cubic contents of the particles of organic matter involved, and the possible protection against solution by

bacterial enzymes afforded by the superficial layer of altered material resulting from their first attack. This argument was strengthened by the observation that in nutrient solutions the fall in rate of evolution of carbon dioxide is much less sudden than where solid particles are concerned. The rate of formation of carbon dioxide is materially affected by the size of particles supplied. Partial sterilization of the soil sufficient to eliminate protozoa does not remove this difference.

Green Manuring. Owing to the difficulty of obtaining even areas of land for field experiments on the farm, it was arranged to take in a comparatively small area of one acre adjoining the outside laboratory of this section; this was divided into 24 plots of equal size and experiments in triplicate laid out for the *kharif* and *rabi* crops of 1914-15; the first was merely a crop of *sanai* (*Crotalaria juncea*) over the whole area; this was applied as green manure, variations in the method of application and their effect upon the succeeding *rabi* crops, oats and tobacco, being studied. As was expected, however, unevenness in this area made it impossible to draw definite conclusions from the experiments as a whole although certain deductions could be made from individual cases; these will be dealt with in the current report on green manuring. Some of the more interesting conclusions were drawn from the use of *seeth* made from *sanai* (*Crotalaria juncea*) the utilization of which had been suggested owing to the difficulty in obtaining indigo *seeth* consequent upon the reduction of area under this crop. It was found that the *seeth water* used in making the *seeth* was roughly equal in manurial value to the *seeth* itself in the case of the *rabi* crop (oats), but that in the residual effect on the succeeding *kharif* crop (maize) the *seeth*, as was expected, proved greatly superior to the *seeth water*. In the case of two areas under tobacco, one with normal and the other with comparatively low moisture content in the cold weather the effect of *seeth* as compared with green manure (*sanai*) ploughed in, in the ordinary way, was greater in the dry area. The differences produced

by green manuring in the rate of ripening both of the oats and of the tobacco were very marked. The effect of superphosphate in conjunction with green manure on the *rabi* crop was marked in soil with good moisture, but inappreciable in plots where the water content was low and the soil itself poor. A large number of observations were made on the changes going on in *seeth* during and after fermentation; it was concluded that the value of this material as a manure depends upon numerous factors of which its nitrogen content is the principal; at the same time great differences in the results may be obtained by proper or improper methods of preparation and application, especially the latter, as large quantities of toxic bodies are produced as a result of the semi-anaerobic conditions obtaining during the early stages of its manufacture, and can totally inhibit root growth if allowed to remain in the soil, being specially injurious to plants in the seedling stage. The time of application appears to be more important than the manner of preparation although these should be interdependent. In the meantime it will be necessary to crop the plots for some time without individual treatment and gain some knowledge of the extent of local variations amongst them. This seems especially necessary in the case of green manuring experiments the results of which are not likely to become strikingly obvious as quantitative differences in the succeeding crop of such an order as to carry them indubitably beyond the range of experimental error.

Studies were made of the development of root nodules on various leguminous plants with special reference to the depth below the surface at which they are formed, the effect of variation in the soil upon their vertical position, and the relation between their development and the age of the plant. With regard to this last, in the case of sanhemp (*Crotalaria juncea*) it was clear that each nodule had its own life-history independent of that of the plant, forming, developing to maturity, and finally shrinking and drying up to an empty shell; cultures and sections from nodules at various stages showed coincident changes

in the conditions of the bacteria and bacteroidal tissue. Nodules in all these various stages of development could be found at the same time on the same plant. Indications were obtained that nodule formation did not take place at that soil level at which most vigorous root growth was found, but tended to occur chiefly where the ratio of air to water was higher than was consistent with maximum root development. A characteristic difference in the character of growth was observed between roots in clay and those in sand, with intermediate variation in mixtures of the two, and similar changes where the plants were grown in alternate layers of these soils. It was remarkable that even in pure sand, nodule development was restricted to a comparatively shallow surface layer very slightly deeper than that found in the case of pure clay.

Sporadic development of nodules, insignificant in number, occurred at deeper levels.

The most universally prevalent characteristic was the fact that at least 90 per cent. of the nodules present at any one time were found on, or very closely adjacent to, the main stem, this being apparently due partly to the fact that such nodules had a longer life than those formed on more distal portions of the root, showing indeed the specific morphological characters associated with their host, and also in part to the fact of this position being coincident with the conditions of aeration which appear to favour their growth. An alternative hypothesis might suggest the importation of the specific *radicicola* organism by the seed and its consequent occurrence in the soil only in the neighbourhood of the latter; this, however, does not appear a probable explanation in view of the indigenous character of the legumes under observation. The general suggestion would be that nodule formation took place more readily in the earliest stages of the growth of the plant owing to the lower power of resistance to bacterial invasion which the latter possesses at that time. Rootlets of a similar age but formed at a later period of growth appear to be less readily invaded.

Azotobacter. Mr. Walton completed the initial stages of his work on *Azotobacter* in Indian soils, the results of which are being published in a Memoir. The preliminary survey showed the occurrence of *Azotobacter* in Indian soils of widely divergent type and situation; the variations in the organism from different localities were not sufficient either in morphological or physiological character to suggest differences of species. Fixation of nitrogen and its increase in amount as a consequence of added carbohydrates was demonstrated in soils in the field. Further work was projected on the symbiotic relationships between *Azotobacter* and soil algæ, some evidence having been obtained of the widespread and highly important nature of this natural source of soil nitrogen, but this has been temporarily abandoned in consequence of the appointment of Mr. Walton to a commission in the Indian Army Reserve of Officers.

IV. Special Enquiries.

Fermentation Organisms. The work on Bákhar was made the subject of a Memoir which was submitted for publication in April. The relationships between the amylo ferments and the Saccharomycetes involved in this question are still being studied.

Yeasts of the cerevisiæ type severally characteristic of the fermentation of *mahua* and molasses were separated from wild types present and supplied for trial to various firms of distillers; no conclusive reports have been received so far, but in the present condition of this industry in India it seems unlikely that much progress will be made of the kind essential for success in Europe, owing to the lack of expert knowledge in the distilleries. The success of the fermentation appears to depend upon its rapidity and consequent comparative freedom from bacterial or other contamination, and this rapid fermentation itself depends upon the use of a large quantity of active yeast; it is therefore upon the successful production of the "mass culture" of yeast that efficiency depends and as the only

methods of effecting this, so far as I know, in India are merely wholesale imitations of European practice, it is not to be expected that total disregard of the very large differences in the conditions under which growth of the yeast takes place in such widely different climates, will lead to any high standard of efficiency. On the other hand, it does not appear probable that any great experience or technical knowledge should be required to make successful modifications and adaptations of European methods to Indian conditions, but some, at least, is essential.

Saltpetre. Experimental work was carried on during the year in order to obtain some knowledge of the biological factors involved in the production of saltpetre in the soils of Bihar. Information was sought for on the following points :—

(1) Why does this industry flourish in particular localities?
(2) Could it be extended either in the places where it is already established or into other districts?
(3) Could the methods of recovering the nitrate from the soil be made more efficient?

The enquiry is still in an early stage, but it seems clear that the leading factors in determining the localities in which this industry can flourish are (1) a high percentage of lime in the soil, (2) suitable climatic conditions for (*a*) nitrification of organic matter, (*b*) accumulation of the nitrates formed.

These conditions are fulfilled in several districts throughout India including the Punjab and the United Provinces but it is in Bengal and especially in Bihar that they are most favourable. It has been ascertained that nitrification goes on during the monsoon in soils containing much nitrogenous organic matter such as occurs in the neighbourhood of villages, and that concentration of the nitrates formed is prevented by the rainfall which carries them down, and allows production to go on in the soil stratum in which conditions of food supply and aeration

favour bacterial action, which would, however, be interfered with by accumulation of nitrate beyond a certain concentration. Such a concentration is found in some of the saltpetre earth collected for extraction by the *nuniahs* and as it is of an order many times greater than that necessary to inhibit nitrification, it is clear that it has not been produced *in situ* by this process, but has been arrived at by the evaporation of weak solutions of nitrates from the soil surface either in the field or on the walls of houses.

The *nuniah* collects *nuni-mati* or saltpetre earth from haphazard sites selected with reference to the accumulations of nitrogen characteristic of village sites and cattle sheds; hence he is dependent on uncontrolled supplies of raw material and any expansion of the industry could only be effected either by introducing the *nuniah* into hitherto unexploited districts or by artificial nitrification of nitrogenous organic matter which would otherwise serve some other purpose. An attempt is now being made to discover the extent to which the carrying out of this latter alternative is feasible. Local enquiry has elicited the fact that the *nuniah* does not generally make his business pay until the second or third year, which he attributes to the fact that the amount of nitrate obtained directly by extraction from the earth collected in the neighbourhood is insufficient on the average to pay expenses, and it is only when the accumulation of residual earth (which after extraction is carefully stored) is sufficient in quantity or suitably matured for a second extraction, that paying quantities of saltpetre are obtained.

If this information proves to be reliable it is obvious that a great deal can be done for the industry simply by ensuring that the time spent in maturing the store of residual earth shall be employed to the best advantage, *i.e.*, that the optimum percentage of organic matter and moisture shall be present, that no leaching by rain takes place, and that nitrification shall not be interfered with by the addition of excessive quantities of salts in solution in the "mother liquor" remaining after concentration,

which it is the *nuniah's* practice to return to the heap of residual earth. This practice may be harmless or even valuable up to a point, after which it must tend to lower the rate of nitrification.

The addition of wood ashes is another practice which probably might be modified with advantage after examination. The addition of organic matter will no doubt prove the most likely source of possible improvement; experiments on this point on a considerable scale are in progress.

Potato Rot. The enquiry into this subject referred to in my report for 1913-14 was completed and a Memoir on the subject was submitted for publication. It was shown that the rotting of potato tubers in store was in many cases due to the action of bacteria common in Indian soils; the conditions under which such bacteria were able to attack the tubers were described and preventive measures recommended. The practice of storing tubers in sand as a protection against potato moth appears to be responsible for many cases of rot in consequence of the increased chances of moisture condensation due to the use of earth instead of sand or imperfect ventilation.

V. Programme of work for 1915-16.

Major Subjects.

(1) Nitrogen fixation by Azotobacter.

(2) Nitrification of organic matter; including conditions severally favourable to ammonification and nitrification.

(3) Green manuring with special reference to organisms responsible for breaking down of buried plant tissues and their conversion into humus, ammonia and nitrates.

Field experiments in green manuring will be carried out in the Bacteriological area attached to the outside laboratory.

(4) Activity of soil bacteria with regard to the rendering available of phosphates and other

mineral plant-foods. This subject will be studied with special reference to the fertilizing action of superphosphate in conjunction with green manures.

(5) Soil Toxins. Bacterio-toxins occurring in soils; their influence on nitrification and the conditions conducive to their formation and destruction; this study is especially connected with the practice of green manuring and the use of organic manures in badly drained soils.

(6) Study of conditions under which saltpetre is formed in Bihar soils.

(7) Biological analysis of soils; a further study of the best means of carrying out this method of investigating soil conditions; this subject forms a principal part of the training of students in this section, the earlier stages being especially designed to allow of familiarization with the methods of obtaining information as to the biological conditions in a soil without undergoing a course of training in purely bacteriological technique.

Minor Subjects.

Study of organisms connected with fermentation.
Such cases of bacterial disease of plants as may arise.

VI. Publications.

The following publications were issued during the year :—

(1) A New Nitrite-Forming Organism, by N. V. Joshi. *Mem. Dept. of Agri. in India, Bact. Ser.*, Vol. I, No. 3.

(2) An article on "Turf," by C. M. Hutchinson. *Agricultural Journal of India*, October 1914, Vol. IX, Part IV.

(3) Report on Agricultural Bacteriology for 1913-14 for the Board of Scientific Advice, by C. M. Hutchinson.

REPORT OF THE IMPERIAL COTTON SPECIALIST.

G. A. GAMMIE.

I. CHARGE AND TOURS.

I held charge of the appointment throughout the year.

Tours. In October, I visited the United Provinces and toured with the Deputy Directors of Agriculture and Economic Botanist.

In November, I visited the Central Provinces and travelled with the Deputy Director of Agriculture and Economic Botanist.

In December, the special trials of Egyptian and other cottons were investigated at Gokak in the Southern Mahratta Country.

In January and February, I was in Gujerat with the Deputy Director of Agriculture working out the characteristics of certain local cottons.

In March, I was in the Southern Mahratta Country working out some details with the Deputy Director of Agriculture.

II. COTTON IN THE PROVINCES.

United Provinces. *Cawnpore.* Mr. Leake's No. 7 is *Gossypium indicum*, var. *Mollisoni*, according to me. This is highly reported on by the trade and it certainly looks very promising. Here the glabrous form of Upland Georgian cotton is known as Dharwar-American and the hairy leaved one as Cawnpore-American.

Conformably with our experience the latter is the more suitable to grow, as it is hardier than the smooth-leaved form, which is also peculiarly subject to insect attacks.

In Dr. Parr's Circle, the Cawnpore-American is surpassed by *Bhuri*, an acclimatized Upland from Chutia

Nagpur. The Cawnpore-American at Cawnpore and elsewhere was originally of many types, but Mr. Burt has now satisfactorily purified it. As the result of spinning trials the cotton is said to be slightly superior to Middling American in all respects except that it has a proportion of short fibres, a character which will probably be eliminated by the methods of selection now being carried on. An increase of 2 per cent. in the ginning percentage is also possible and desirable.

Kalai. Here Mr. Leake has a well-arranged farm for growing his types and selections on a fairly large scale. This farm will serve as a centre of distribution of a pure supply of seed of the following varieties :—

(1) A white-flowered indigenous cotton fit for the use of the eastern parts of the Provinces.

(2) No. 7 or the white-flowered *indicum* which is being successfully introduced into Bundelkhand.

(3) A red-flowered cross which will eventually replace the inferior but highly productive white-flowered cotton of this tract.

(4) A large bolled variety of smooth-leaved Upland from Persia. This is not promising and it will probably have to be abandoned.

I visited several localities in which Bhuri cotton is grown, in the company of Dr. Parr and I agree with him in thinking that it is quite suitable for this tract.

Cotton operations in the United Provinces can be summarized as follows :—

In Mr. Burt's Division. The introduction of Cawnpore-American into localities with good soil and irrigation; the extension of No. 7, throughout Bundelkhand; the introduction of an early-maturing variety for the eastern parts. This, at present, is being evolved by Mr. Leake.

In Dr. Parr's Division. The present extension of the white-flowered indigenous cotton in place of the prevalent

mixture. This he hopes to supplant in time with Mr. Leake's improved red-flowered cotton; the extension of *Bhuri* as a higher class cotton in the favourable localities; a possible improvement of one yellow-flowered indigenous cotton at least.

Distribution of improved seed. It is satisfactory to note that this has received careful attention and I approve of the method now being worked out by Dr. Parr in the Western Circle. In this there are a large number of spring wells, giving a discharge of from 8,000 to 20,000 gallons an hour. It has been shown that this water can be raised more cheaply by oil-engines and centrifugal pumps than by bullocks. As a result, a large number of *zamindars* and cultivators are putting down pumping plants on their wells. Government is assisting by giving *takavi* for this purpose. These installations are doing very useful work directly, that is, in pumping water cheaply. They are also going to prove extremely useful in facilitating the supply of improved seed introduced by the Department. I will confine my further remarks to the needs of the cotton crop. Many of these oil-engine owners are being induced to put down cotton gins. At present it is hoped that for every one hundred thousand acres of cotton grown, there will be about twenty-five oil-engines, each with a cotton gin attached. The oil-engines vary in size according to the amount of water in the wells and the depth of the water from the surface, but each will command on an average about fifty acres of cotton, that is to say, there will be twenty-five seed-farms each growing fifty acres of cotton or a total of 1,250 acres. The produce of this area will sow about 18,750 acres in the following year so that these seed farms will supply seed to the total area of one hundred thousand acres once in about five years. No hard and fast rule need be laid down. If it seems advisable to cover the area more often, many more centres where pumping installations are working, will be available. To supply the twenty-five seed farms or the total private seed-farm area of 1,250 acres, an area of eighty acres will be

required. This will be entirely under the control of the Agricultural Department.

The private seed-farms will gradually establish a reputation as suppliers of good seed. The crop will be grown, the ginning done and the seed supplied at first under some supervision from the Agricultural Department. But it is hoped that gradually supervision will become unnecessary and a private seed supply agency will grow up and relieve the Agricultural Department of what is at present one of its most onerous duties.

My assistant, Mr. Mankad, also independently visited the Provinces and furnished notes supplementary to my own. The types grown at Cawnpore under numbers are thus understood by us.

I. *G. obtusifolium*,
II. *G. herbaceum*,
III. *G. arboreum*,
IV. *G. indicum* (true) with yellow flowers,
V. *G. neglectum*, broad-lobed, yellow flowered (var. *Malvensis*),
VI. *G. neglectum*, broad-lobed, white-flowered, with branching habit,
VII. *G. neglectum*, broad-lobed, white-flowered (*G. indicum* var. *Mollisoni* according to us),
VIII. G. *neglectum*, narrow-lobed, with yellow flowers (var. *vera*),
IX. *G. neglectum*, narrow-lobed, white-flowered (var. *rosea*),
X. Assam or Kil cotton,
XI. G. *sanguineum*, with pink flowers.

The Economic Botanist has numerous crosses and one between *arboreum* and *Mollisoni* has been worked up to a field scale. His object is to produce, if possible, a type possessing the following characters:—(*a*) early maturity, (*b*) heavy outturn, (*c*) high ginning percentage, (*d*) superior quality of fibre, (*e*) cotton with naked seed. To achieve the last object he has selected a long fibred type of Chinese cotton which has naked seeds, and this is used for crossing.

Type VII comes to maturity early and gives an average outturn of 800 lb. seed cotton with a ginning percentage of 33 to 34 and staple averaging three-fourths of an inch.

The cross *arboreum* × *Mollisoni* gives an outturn of 600 lb. seed cotton, with a ginning percentage of 33 and staple of about three-fourths of an inch. This cross, which resembles *Sanguineum* in all respects, is now in its fifth year and it is intended to start distributing its seed.

At the Kalai Farm Type VII is grown on 35 acres.

The crosses put out are:—(*a*) *arboreum* × *roseum*, purified white-flowers; (*b*) *arboreum* × *roseum*, purified yellow-flowers, seventh generation; (*c*) *arboreum* × *roseum*, purified pink-flowers; (*d*) *arboreum* × *indicum* var. *Mollisoni* (Type VII), pink-flowers, narrow-lobed; (*e*) *arboreum* × *Mollisoni*, red-flowered, purified.

At Cawnpore, under Mr. Burt, Black Rattler and other fancy types of American cottons have been tried with fresh seeds obtained from America but so far they show no promise.

Bhuri seemed hardier and better in growth than Cawnpore-American and also higher in ginning percentage. The fibre of both, however, seemed weak.

On the seed farm *roseum* appeared more promising than either Type VII or Cawnpore-American.

At Aligarh, the white-flowered local cotton (*roseum*) seemed better than Type VII. This gives an average outturn of 800 lb. seed cotton, with a ginning percentage of 37 to 38. The cultivators in this Circle have been independently selecting white-flowered cotton seed. It is possible that in the future the whole of the cotton in the tract will consist solely of this.

The conclusions arrived at by Mr. Mankad are that (1) the local cottons are the same as those of Sind (a tract with which he is familiar), but *less hardy*. (2) Of the pure types, *indicum* var. *Mollisoni* and *roseum*, the former produces the better staple, but is poorer in ginning percentage, (34) the latter gives a very high ginning percentage and it

is hardier. (3) Of the crosses, *arboreum* × *Mollisoni* is promising. It resembles *sanguineum* in all respects. Mr. Mankad has not personally seen the Mooltan cotton but from samples of it received from Lyallpur, it appears to him that cotton of this cross is lacking in *colour* although it has a finer staple. Of the American types, Cawnpore-American and *Bhuri*, he does not think that either will really succeed in this tract.

Central Provinces. At Telinkheri Farm the most promising selection is a cross between *Bani* and *roseum*.

The selections of *roseum* vary in percentage from 41 to 43.

Cambodia seems to ripen too late for this tract.

Allen's Long Staple is not promising.

At Tharsa, there is a very well-grown plot of *roseum* and there is no particular reason why it should not do well in this locality. At Chhindwara, an Upland cotton has produced beautiful bolls in Mr. Lawrie's orchard and that gentleman has promised to save the seed and put it out on a large scale. At the Seoni Farm the cottons are early ripening *Chapra* and *Saugar*. They are most suited for this tract. They are also being grown to demonstrate the advantages of drilling over broadcasting which is the local method. It is to be hoped that the people will follow the excellent examples shown on this farm. The *kamdar* is a particularly intelligent man and has a very clear idea of the nature and value of the experiments under his charge. At Sindewahi, Cambodia and *roseum* are being tried under irrigation on *wardi* soil. This is the third year of the trial on a large scale. Last year, under irrigation and manuring, the crops were 1,000 lb. of Cambodia and 1,200 lb. of *roseum*. The cotton was of a good quality. So far the cultivators hesitate between the claims of rice and cotton. This is not really a cotton-growing tract and it would only partially replace rice in the event of cotton prices ruling high. Mr. Clouston has hopes of a cross between *deshi Lahore* and *roseum*. It is valued at 8½ per

cent. more than Hinghanghat. *Roseum* everywhere is a strong competitor against *Bhuri*, which will be restricted ultimately to wilt-infected areas.

Cotton from the Sindewahi Farm was reported on as follows by Messrs. Tata and Sons of Bombay :—

Roseum. Compared with roseum grown on the Akola Farm, it is a little longer in staple and softer in feel, though the class is dull. Can spin up to 12's. Value Rs. 190 per candy or equal to the price of Akola cotton on the day.

Bani × *Deshi Lahore.* Seems to be a little better in staple than the same variety sent from the Akola Farm, though not so bright as the other. Can spin up to 22's and 24's. Value Rs. 240 per candy.

Cambodia. Compared with *bani* of the Akola Farm it is weaker in fibre and a bit shorter in staple. Can spin up to 30's. Value Rs. 260 per candy.

An analysis of these valuations based on the acreage outturn of seed cotton and percentage of cotton to seed shows that in actual values the three varieties from Sindewahi stand as follows :—

Roseum, Rs. 65 per acre.
Cambodia, Rs. 59 per acre.
Bani × *Deshi Lahore*, Rs. 40 per acre.

On the same basis nine varieties of cotton received from the Akola Farm stand as follows :—

	Per acre Rs.
(1) *Bani* × *Deshi Lahore*	58·14
(2) *Gossypium neglectum*, var. *rosea* .	53·3
(3) *Gossypium neglectum*, var. *Cutchica* .	50·2
(4) *Gossypium neglectum*, var. *Malvensis* .	33·14
(5) *Gossypium hirsutum*, var. *Bhuri* . .	32·6
(6) *Gossypium neglectum*, var. *vera* . .	31·4
(7) *Gossypium indicum* (Bani) . . .	30·10
(8) *Gossypium neglectum* (Berar Jari) .	29·5
(9) *Gossypium neglectum* (Saugor Jari) .	26·13

Bombay: Southern Mahratta Country. After my visit to Gokak Agricultural station to inspect and report on some interesting experiments conducted by Mr. Kottur, I submitted the following note.

Egyptian cottons. In 1908-09, Abassi was grown. The plants were very vigorous and tall and gave good cotton. In 1909-10, the plants were stunted and were attacked by red-leaf blight. In 1910-11, Abassi and Meta-Fifi were both tried with seed procured from Sind. The plot became water-logged, the plants were attacked by red-leaf blight and the outturn was small. In 1912-13, the plants were moderate. This year they have done better. Mr. Kottur thinks that, by selection, he can finally make the cultivation of Egyptian cotton in Gokak a success and, as he is endowed with the spirit of independent research, I recommended that he should be encouraged to persevere. In this tract, cotton is grown under irrigation on four thousand acres out of an area of forty thousand acres, so in the event of success a large area could be put out under a high class cotton.

Cambodia cotton suffers from red-leaf blight. It gives a good yield under a low rainfall and a bad one under a heavy rainfall. The crosses from Nadiad-Abassi × Bourbon, Bourbon × Abassi, Abassi × Cambodia are not promising and they are becoming later in ripening. Broach cotton is only fairly satisfactory. Selected Kumpta does well. The local variety *kumpta* is the most to be depended upon under all conditions. Under irrigation it yields up to six hundred and seven hundred pounds of seed cotton per acre.

The following observations made by Mr. Kottur on Meta-Fifi sown from seed imported from Egypt by me are interesting as showing differences caused at once by a new environment :—

(1) The height of the plant, instead of being eight feet, is from four to five feet.

(2) Instead of bearing numerous long, upright, basal branches, it has none or very short ones.
(3) Instead of the fruiting branches being produced only above the middle of the plant they are produced from one-third the height of the plant upwards.
(4) The plants are glabrous.
(5) The teeth of the bracteoles, instead of being short, are long.
(6) The colour of the flower is light yellow and not bright lemon yellow.
(7) The length of the petals, instead of being two inches, is one and a half to one and three-quarters inch.
(8) The bolls in most cases are not well-filled, the tops being often blunt.
(9) The number of cells (locks) is three in all cases.
(10) The staple is one-half to one inch long.
(11) The covering of the seed varies. It is green-tufted at both ends, or only so at the tip; brown-tufted at both ends; brown-tufted at the tip only; and almost naked.

Although the seed was procured from a reliable source in Egypt it is quite probable that I may not have been supplied with the real article, and all the above differences may not arise from altered conditions.

The opinion of Messrs. Tata on a sample of Egyptian cotton from Gokak Farm is as follows :—

It is a long stapled excellent cotton having all the characteristics of Egyptian. We have no basis to value this cotton.

Broach cotton at Dharwar. There is now the eleventh generation of Broach. The percentage of cotton to seed has fallen to 29. The crop ripens almost as early as that of Kumpta. Mr. Kottur has detected eight different shapes of bolls in the Broach cotton. He is to sow the seeds from each of these separately so as to ascertain whether any differences will ultimately occur in ginning percentage and other factors.

There are four experiments being conducted on this farm in connection with Broach cotton :—

(1) *Shevri* (*Sesbania ægyptiaca*) and *jowar* used as wind-breaks. Owing to the absence of easterly winds this year the results are indefinite. As it has had effects on contiguous crops, *shevri* should be removed and the *jowar* alone kept on.

(2) To test the prevailing idea that *jowar* follows Kumpta more profitably than it does Broach. (Last year's conclusion served to prove that *jowar* follows Broach just as well as it does Kumpta.)

(3) Wilt disease. It has only appeared this year and is increasing in Broach cotton, especially in that from the new seed.

(4) Deep *versus* shallow ploughing.

Subsidiary tests are in progress to find out whether *jowar* sown in August will come on as quickly as that sown in July, the difficulty at present being that the cultivators say they cannot get their fields ready in July for sowing *jowar* after Broach cotton.

Very little of the Broach cotton produced by members of the Agricultural Association ranked as first class in the auction. They should not be discouraged by this failure but repeat the experiments in more carefully selected areas.

The members of the Association have also imbibed the idea that Broach has a bad effect on the succeeding *jowar* crop. The experiments on the farm (already referred to) may reassure them on this point.

Mr. Mankad has the following note on the sale of Broach cotton which took place on the 16th May 1915 at Dharwar :—

" In all, 39,000 lb. of seed were distributed covering an area of about 2,500 acres (10,000 lb. fresh seed imported from Navasari and 29,000 lb. from the special class of the auction sale of last year).

The cultivation of this cotton is chiefly confined to Dharwar, Hubli, Bankapur and Haveri Talukas of the Dharwar District and the Sampgaon Taluka of the Belgaum District.

Sowing took place in July as well as August. Heavy continuous rains spoiled especially the black soil area bordering Malad so much so that the crop had to be grubbed up and the area had to be put out under wheat. The shedding of the leaves was tremendous and the bolls dropped down; the opening was also unsatisfactory. The average yield in this area, *viz.*, the black soil area bordering Malad, was very disappointing—50 lb. per acre only.

In the eastern portion of the black soil area bordering Malad the yield per acre averaged 200 lb. *kapas*. The crop did not suffer much in these parts as the rains were not very heavy. The late rains in January and February were most unfavourable for all cotton crops and especially to Broach. The excessive moisture at that time induced the plants to throw out more of leafy and woody growth and the bolls already formed did not open at all.

Picking was very leafy. The local cotton Kumpta was also a six anna crop.

The total number of *dhokadas* of Broach cotton received at the Depôt was 1,274.

The cotton was graded in six classes according to ginning percentages and the following prices were obtained per *naga* of 1,344 lb. *kapas*:—

Class	Ginning per cent.	Price per *naga*
		Rs.
Special	*Nil*	*Nil*
1st	33·5	150
2nd	32·5	143
3rd	31·5	136
4th	30·5	127
5th	29·5	124
6th	Rejected Broach	110

The local cotton Kumpta on the day stood at Rs. 107 per *naga*.

In addition to Broach cotton 438 *dhokadas* of Kumpta cross having a ginning percentage of 27·5 and 26·5 got Rs. 110½ and Rs. 108½ respectively per *naga* of *kapas*.

The prices were offered from the point of ginning percentages. Broach cotton graded in Class IV was stronger and better in colour than that of Classes I and II.

The ginning percentage of Kumpta cross was very low this year owing perhaps to the deterioration of the variety due to local seeds being used every year. No seed was therefore bought back this year. Similarly the ginning percentage of Broach was low this year.

It will be seen from the statement that not even one *dhokada* has come in the special class. The number of *dhokadas* even in the first class was very small, *viz.*, 52.

All the Broach cotton was purchased by Mr. Jijibhai Ardeshiar Dewecha who was specially deputed by Messrs. Tata, Sons & Co., Bombay.

It is proposed to get about 3,000 lb. fresh seed from Navasari and to obtain all seed from the first class of the sale at 40 lb. a rupee (this will give about 10,000 lb.) so that in all there will be about 13,000 lb. for distribution this year. From the quantity of seed intended for distribution it seems that the area under Broach cotton will considerably fall this year."

Messrs. Tata make the following valuations and remarks on six samples sent from Dharwar :—

Serial No.	Name of Variety	Remarks
1	Kumpta from plot 608	No. 2 is in every respect superior to No. 1. No. 1 can spin up to 24's and No. 2 can spin up to 32's. Value No. 1, Rs. 230. No. 2, Rs. 245.
2	Kumpta selected for quality.	
3	Kumpta cross . .	No 3 is superior to No. 4—especially in strength of fibre. Can spin up to 24's. Value No. 3, Rs. 240 and No. 4, Rs. 235.
4	Kumpta × Ghogari	
5	Broach first generation	No. 5 is decidedly superior to No. 6. No. 6 has much deteriorated. No. 5 can spin 40's. Value Rs. 260. No. 6 can spin up to 30's. Value Rs. 240.
6	Broach 11th (last) .	

Basis of prices per candy of 784 lb. on 21st July 1915 :—

	Rs.
Kumpta (mixed)	210
Kumpta (pure)	230
Navasari	260
Surat	240
Broach	220
Saw-ginned	215
Cambodia	240
F. G. Mathia	160

By analysis of the market valuation and acreage on them these samples stand in the following order :—

	Value per acre Rs.	A.
(1) Kumpta Cross	61	9
(2) Kumpta selected for quality	56	3
(3) Broach (11th generation)	44	11
(4) Kumpta (from plot 608)	43	11
(5) Kumpta × Ghogari	40	9
(6) Broach (1st generation)	17	0

Exotic cottons at Gadag. *New Orleans*, imported from the United States of America, in 1908, does not differ now from Dharwar-American. The seed, at first naked, is now fuzzy.

Allen's Long Staple is coming down to the local percentage and Boyd's Prolific has changed in the same way.

Texas Long Staple is maintaining its percentage better.

Texas Long Staple and Allen's Hybrid are the best of the exotics at Gadag. They ought to be put to the test on a larger scale, as soon as possible.

Dickson, Peerless and Cook are also to be tried on a larger scale next season.

In alternate lines of Dharwar-American and Cambodia evidence of inter-crossing is apparent to the extent of one per cent. The belief is gaining ground that Cambodia is more suitable than Dharwar-American for dry areas.

Dharwar-American. New Orleans type comes true. It is later in ripening than the true Upland form. The staple seems better than that of Upland although the latter was valued more highly in the market.

The Upland has a ginning percentage of about 30, the New Orleans 28.

The Upland type is being grown pure in the Ranebennur Taluka by Mr. Kottur. The two varieties are grown mixed in Gadag and Ron Talukas.

The following is a note on the auctions drawn up by Mr. Mankad :—

"The auction sale of Cambodia *kapas* was held at Gadag on the 9th May 1915. In all 20,000 lb. of Cambodia seed were reserved for distribution purposes, 3,000 lb. from the Gadag Farm and the remaining 17,000 lb. from the purified lot of the special class of the auction sale of last year. Of this quantity, about 7,500 lb. to cover about 400 acres were sown in the Gadag and the Ron Talukas. The same quantity was intended for the villages of the Bijapur District, but on account of the suggestion made by the Government to put out larger areas under cereals, only half the quantity was distributed chiefly in the village of Kundergi in the Bagalkot Taluka and the villages of Mangoli and Muttigi along the Don river where the conditions seem more favourable. The area under Cambodia cotton in the Bijapur District will be roughly 200 acres.

Sowing was done from the end of September till the first week of October. On the whole the season was not unfavourable to Cambodia cotton in the Gadag and the Ron Talukas of the Dharwar District but it proved very unfavourable to the Dharwar-American. In the Bijapur District, however, the crop suffered on account of abnormally heavy rains.

With regard to the sowing period, it seems that Cambodia in the District thrives much better when sown in the beginning of October. The experience gained on the

Gadag Farm shows that Cambodia gives better results when sown in the middle of September. The Divisional Inspector of Agriculture has taken up this matter of finding out the right season for sowing as a special study.

The District Agricultural Officers during their tour in connection with the inspection of the corp have found Cambodia thriving much better in the village of Sudi in the Ron Taluka and in the villages of Kurtkoti and Hulkoti of the Gadag Taluka than in other places. The soil and other conditions do not materially differ and the comparatively poor progress of the Cambodia cotton in other places requires careful investigation.

The outturn per acre varied from 400 lb. to 100 lb. *kapas* with a ginning percentage from 32·5 to 37. In some well-cultivated fields at Sudi the yield was 600 lb. per acre, while the yield of Dharwar-American was not more than 500 lb. in any fields. Experience shows that Cambodia thrives in years when the rainfall is moderate.

I am strongly inclined to believe after examining the cotton that the staple of the Cambodia cotton has not only become weak but has considerably deteriorated in length also, *i.e.*, the staple is both weak and short. Unless selection work is undertaken, I am afraid that this cotton will lose its reputation. Experienced cultivators say that the cotton bolls are now becoming smaller in size than they were when the cotton was first introduced.

The varying results of Cambodia cotton would always be a strong factor against the possibility of its extension in larger areas; the extension will also remain limited, as the Dharwar-American cotton is very promising in the Ranebennur Taluka and the adjacent parts.

All the *kapas* was not received at the auction depôt, as the needy cultivators cannot wait till the auction sale is arranged for.

In all 1,189 *dhokadas* (4 Dhokadas = 1 Naga = 1,344 lb.) were received at the depôt. The cotton was graded in six classes according to the ginning percentages.

The prices offered for each class are given below per *naga* of 1,344 lb. :—

Class	Ginning percentage	Price
		Rs.
Special . . .	37 and above .	154
1st	36·5 . . .	145
2nd	35·5 . . .	146
3rd	34·5 . . .	140
4th	33·5 . . .	140
5th	32·5 . . .	135
Unclassified . .	. . .	132

The price of Dharwar-American on the day was Rs. 108. The prices realized are mostly from the point of ginning percentage.

It is proposed to purchase all the seed of the special class at 36 lb. a rupee, and about 1,000 lb. will be available from the Gadag Farm; so that the total quantity available for distribution this year will be about 10,000 lb.

With regard to the prospects of Cambodia and Broach cottons in the Southern Division, it can be said that :—

The two varieties of cottons have not been well established, as yet. In some favourable seasons they give excellent yields, while in some, they yield less than the local Kumpta. In some years there is timely rain for sowing the Broach variety early in July, while in others, the sowing season is unfavourable either through insufficient or too much rainfall. Similarly heavy late rains spoil Cambodia crop. Besides, there is a belief that the Broach crop impoverishes the soil and the following crop of *jowar* becomes very poor.

The percentage of lint also varies according to the nature of the soil though the seed sown is of very superior quality. Notwithstanding the above adverse conditions, people have a tendency to sow Broach cotton at least on a small scale and this tendency is due to the high price ensured to them by holding an auction sale by the Department.

The present high rate given by merchants in the auction sale is for the following reasons :—

(*a*) A large quantity of Broach and Cambodia *kapas* is gathered at one place by the efforts of the Department;

(*b*) The *kapas* is graded and there is a sort of guarantee for the declared percentage of lint;

(*c*) There is some Departmental check over the cultivators not to adulterate the cotton with other inferior varieties.

When the auction sale is stopped, merchants will not have the facilities mentioned above and the mill-owners will not be induced to buy the *kapas* at such high rates. The only merchants on whom the Broach and Cambodia cotton growers will have to depend, will be the local middle men, who, when they understand that there would be no auction sale, would offer as low a price as possible.

The only solution to continue the cultivation of Broach and Cambodia cottons in the absence of auction sales by the Department would be either :—

(*a*) that the cultivators should gin their own *kapas* and sell the lint, or

(*b*) that some organized bodies like the Agricultural Associations or Co-operative Societies should take up the work of arranging the auction sales on the same lines as is done at present by the Department.

The former appears to me to be impracticable. As regards the latter, it is a question whether the Agricultural Association, Dharwar, can undertake this sort of work independently.

I understand that the holding of auction sales has been financially successful to the Department. Besides, the work brings the Departmental Officers in close touch with numerous cultivators and cotton merchants. The expert merchants and mill-agents consider that the Broach cotton grown at Dharwar is as good a cotton as that grown at

Navasari or sometimes better. They have all along been giving good prices to encourage the cultivation and are still ready to continue the same. In the last auction sale Mr. Jijibhoy Ardeshiar Dewecha, Manager, Swadeshi Mills, Bombay, expressed his opinion that the cotton was very good and he would be glad to buy up to 10,000 bales of such cotton grown in the Southern Division.

In conclusion, it seems highly desirable that, until the cultivation of these two cottons becomes permanent on an extended scale, the auction of these should be continued by the Department. Similarly the steady supply of good seed (a large quantity from Navasari) will also have to be undertaken annually by the Department."

Messrs. Tata have the following valuations and remarks on six samples of cotton from the Gadag Farm :—

Serial No.	Name of Variety	Remarks
1	Dharwar-American—New Orleans type.	Both are far superior to Ordinary Saw-ginned Dharwar especially in length and strength of fibre. They have retained some characteristics of American. No. 2 is weaker in fibre than No. 1.
2	Dharwar-American—Upland type.	No. 1 can spin up to 40's. Value Rs. 260. No. 2 can spin up to 30's. Value Rs. 245.
3	Dharwar-American Ordinary.	It is ordinary saw-ginned. Can spin up to 20's. Value Rs. 215.
4	Cambodia, saw-ginned	No. 4 is so nicely ginned that the staple does not seem to be cut as it ordinarily ought to appear. The length of staple almost equals that of No. 5, roller ginned. Can spin up to 32's. Value both Rs. 240.
5	Cambodia Double Roller-ginned.	
6	Christopher × Culpepper.	It is superior to Nos. 4 and 5 especially in strength of fibre. Can spin up to 40's. Value Rs. 260.

Bases of prices are the same as those given for the six samples of Dharwar above.

An analysis of the valuations and average outturn places the Gadag samples in the following order :—

	Per acre Rs.	A.
(1) Dharwar-American, New Orleans type .	33	4
(2) Christopher × Culpepper	31	9
(3) Dharwar-American, Ordinary . . .	29	2
(4) Dharwar-American, Upland type . .	22	6
(5) Cambodia, saw-ginned	19	8
(6) Cambodia, double roller ginned . .	19	8

Karkeli cotton. This was tested at Bhilvadi in the Tasgaon Taluka of the Satara District by the Inspector of Agriculture, Sholapur.

The outturn of seed cotton was 204 lb. The Inspector says that the outturn was poor owing to the want of rain at the time of sowing, and from heavy rain after sowing. The germination was hence not satisfactory. The ginning percentage was 30.

Messrs. Tata made the following remarks on a sample of this cotton :—" It seems to have deteriorated a little in length of staple. Can spin up to 32's. Value Rs. 210 (Karkeli of the day Rs. 215)."

An analysis of the outturn and value gives the crop a value of Rs. 16-5-0 per acre.

Cottons at the Agricultural College Farm, Poona. Three cotton varieties, Cambodia, Bhuri and Broach are being tested on this farm. The valuations of all are identical and Broach, although it yields the heaviest crop, is falling off in percentage.

Messrs. Tata report as follows on samples :—

1. Cambodia . . .	This cotton has somewhat deteriorated in length of staple. It is rather coarse in feel. In other respects it has retained its characteristics. Value Rs. 230 (Cambodia of the day at Rs. 240).
2. Bhuri . . .	Same as above but a little better in feel. Value Rs. 230.
3. Broach . . .	A little better than Fine Broach. Compared with Navasari grown in the District has deteriorated. Value Rs. 230 (Fine Broach of the day Rs. 220).

The value of the crops stands as follows :—

	Per acre Rs.	A.
(1) Broach	60	6
(2) Bhuri	50	9
(3) Cambodia	46	15

Gujerat. The selected cottons are being grown by villagers round Surat on about 400 acres. There appears to be a consensus of opinion that the selected cottons are really superior to the prevailing article.

The Superintendent of the Surat Farm says that prices fluctuate in different centres of the District and cotton grown in the north invariably fetches a lower price than that in the south. Cultivators gain by taking the trouble to cart their cotton to the centre offering the highest price.

Ghogari exists as an appreciable mixture in Broach but not in Surat cotton.

The Superintendent also emphasized the fact which is true, *viz.*, that the Surat District is peculiar in that its conditions do not suit any outside variety of cotton so that cultivators would lose if adulteration of seed occurred. So far as we see then, Surat and Navasari cotton will always be grown pure and if contamination appears in the marketed product, it must take place after it leaves the cultivator's hands.

The Superintendent also assures me that the bulk of the Surat and Navasari cottons is bought forward by agents from the Ahmedabad Mills before the Bombay traders appear on the scene and that all the Broach cotton of the Bombay market is really grown in the Broach District. The prices offered by the Ahmedabad merchants are in advance of those offered from Bombay. It might be as well for the Department to bring its improved cottons to the direct notice of the Ahmedabad mill owners.

In *ghogari* the seed is larger than that of *deshi* and the cotton is more adherent so that it is more difficult to gin. The fuzz is white, while that of *deshi* is brown.

As a result of an inspection of many fields of cotton in the Jambusar Taluka of Broach we found that *ghogari* was grown in a very pure state. The prevailing form is round bolled and only a few plants with pointed bolls were found. In the event of a seed farm being established here to improve *ghogari* cotton, distribution could be easily arranged, as the villagers would naturally accept seed which is even only a little better than their own. There is sufficient land in the close vicinity of Jambusar town alone to provide area for seed farm purposes.

In Vavli village the cultivators co-operate in having their cotton ginned under their own supervision so that they are certain of getting back their seed pure. The difference in yield of clean cotton in *ghogari* as against *Broach Deshi* is 14 per cent.

The point to be decided was whether the farm at Broach is suitable for the improvement work in *ghogari* or whether it could be done more efficiently at Jambusar. It is known that *ghogari* bolls open badly in the real black soil but on the Broach Farm, where the soil is intermediate in character, this drawback is not encountered. It is therefore quite practicable to effect the selection at Broach for the whole of the *ghogari* tract and villagers round Jambusar would, no doubt, willingly agree to grow pure *ghogari* for seed distribution.

There are four types of *ghogari* cotton to be tested :—

(1) The first and typical has a large, round boll, with a high percentage of lint, which clings tightly to the seed which has a white fuzz. This will probably be the form ultimately selected.

(2) The second is a large, pointed boll, and the lint does not cling so closely to the seed. The fibre is finer and the fuzz is *brown.*

(3) and (4) are small bolled equivalents of (1) and (2).

On account of its high ginning percentage, its proportion in *Broach Deshi* mixture is steadily increasing and it would be safe policy to see that the cultivators get a hold of the best *ghogari* that can be developed.

Surat. Of the four cottons sent for evaluation from this centre, taking into consideration their outturns and ginning percentages, they stand in the following order :—

	Per acre Rs. A.
(1) Selection II—General . . .	58 12
(2) Selection I-A.	53 4
(3) 1027 A L F	50 6
(4) Surti Broach Local . . .	46 11

These figures prove that any one of the three selections is considerably in advance of the ordinary local cotton (the last) and it would pay the cultivator to take them up.

Sisodra Plot. In the Sisodra plot two of the above named varieties again come in and the three stand in the following order :—

	Per acre Rs. A.
(1) 1027 A L F	36 11
(2) Selection I	30 5
(3) Local Sisodra	29 12

There must be some good reason for the discrepancy in the value of the cottons from this plot as compared with those from Surat. It is probable that the cotton from Billimora and Chikhli furnishes the best so called Navasari cotton and that the product from Navasari itself is not quite so good as this.

Broach Plot. We have already noticed that the prevailing form *ghogari* is round-bolled and that only a few plants have pointed bolls. It is interesting to find from the market valuations that the commoner form yields the better cotton.

Next season when we will have outturn results from the two types of *ghogari* we may be able to say definitely which is the more profitable to grow.

Nadiad Farm. The acreage value of the indigenous *lalio* is Rs. 85-9 against Rs. 77-12 in Cambodia. This goes to prove that in the long run the local cotton will pay the cultivator best.

Madras. Although not requested to do so, I have taken the liberty of obtaining the expert opinion of Messrs. Tata, of Bombay on the cottons grown in the Presidency, samples of which were supplied for museum purposes.

Four samples of *karanganni* were received from Koilpatti Agricultural Station, of which three were special strains. The price of Tinnevelly for the day being Rs. 235, the ordinary *karanganni* sample with the percentage of

cotton to seed of 24, was valued at Rs. 220; Company No. 1 with percentage 27, valued at Rs. 245; Company No. 2 with the percentage of 31, valued at Rs. 240; Company No. 3 with the percentage of 33, valued at Rs. 235 per candy of 784 lb. There has been an increase of 9 per cent. in the percentage and an increase of Rs. 25 in the price. If the acreage results had been supplied, we should have been in a position to give the actual value of the cotton produced per acre.

Pulichai cotton is so largely contaminated with Berar seed that it is valued at the same figure. Company No. 2 (*Karanganni*, special selection by Mr. Sampson from last year's crop) is valued at Rs. 248, Tinnevelly of the day standing at Rs. 235.

The Cambodia samples from Koilpatti and Coimbatore were valued a little below the price of good Cambodia in Bombay.

Samples of *uppam* from Koilpatti and Coimbatore are valued at Rs. 205, the ordinary market rate. Bourbon from Coimbatore is valued equal to Navasari cotton at Rs. 270 and *nadam* from Coimbatore stands equal to Westerns at Rs. 200.

With Westerns selling at Rs. 200 in Bombay, the sample from Hagari was valued at Rs. 215.

With Northerns standing at Rs. 210, white-seeded Northerns from Nandyal was valued at Rs. 230; black-seeded Northerns from the same place at Rs. 225.

Coconada standing at Rs. 210, Yerrapatti red was valued at Rs. 215 and Coconada red, Rs. 205 and white Coconada from Samalkota, at Rs. 215.

Messrs. Tata make the following valuations and remarks on these samples :—

Basis of prices per candy of 784 lb. on 11th August 1915 :—

Tinnevelly, Rs. 235 : Uppam, Rs. 205 : Westerns, Rs. 200 : Cambodia, Rs. 240 : Northerns, Rs. 210 : Navasari, Rs. 270 : Berar Jari (Akola), Rs. 200 : Coconada, Rs. 210.

Serial No.	Name of Variety	Remarks
1	Ordinary *Karanganni* .	Of these four samples, No. 2 is best, Nos. 3 and 4 are alike, but a little bit inferior to No. 2 in length of staple. No. 1 comes last, being short in staple. Nos. 2, 3, 4 can spin from 30's to 32's. No. 1 can spin up to 24's. Value No. 1, Rs. 220; No. 2, Rs. 245; No. 3, Rs. 240; No. 4, Rs. 235.
2	*Karanganni* Special type Company No. I.	
3	Do. Company No. II.	
4	Do. Company No. III	
5	*Pulichai cotton* . .	This resembles Akola cotton. It is a short staple cotton. Can spin up to 16's. Value Rs. 200.
6	Tinnevelly cotton .	It is a strong, silky, good staple cotton more or less equal to Nos. 3 and 4. Can spin up to 30's. It is not *Uppam* as it is supposed to be. Value Rs. 235.
7	*Company No. 2*—Special Selection.	This is more like No. 2 but more silky. Can spin up to 32's. Value Rs. 248.
8	Cambodia from Koilpatti.	No. 9 is a bit longer in staple than No. 8. Both are silky, long stapled cotton. The fibre is weak and therefore cannot spin more than 32's. Value Rs. 235 for each.
9	Cambodia from Coimbatore.	
10	*Uppam* from Koilpatti	Both are alike coarse, short stapled, No. 11 being a bit whiter in colour than No. 10. Value Rs. 205 for each. Can spin 12's to 14's.
11	*Uppam* from Coimbatore.	
12	Bourbon from Coimbatore.	It is a long stapled, silky cotton. Can spin up to 40's. Value Rs. 270.
13	*Nadam* from Coimbatore.	It is very variable in length of staple and may be valued at Rs. 200. Can spin up to 16's.
14	White-seeded Northerns from Nandyal.	Both are silky long stapled cotton and strong fibred. No. 14 being whiter than No. 15, which is Red, No. 14 may be valued at Rs. 230 and No. 15, Rs. 225. Can spin up to 32's.
15	Black do. do.	
16	Yerrapatti Red . .	This is softer in feel and a bit longer in staple than Red Coconada. More suitable for dyeing. Value Rs. 215. Can spin up to 20's.
17	Coconada Red . .	Both are red and white ordinary types of Coconada. The fibre is coarse and staple shorter than No. 16. Can spin up to 16's. Value No. 17 (Red), Rs. 205. Value No. 18, for its colour Rs. 215.
18	Coconada white from Samalkota.	
19	Westerns from Hagari .	For Westerns, the staple is very good, being very long. Can spin 24's. Value Rs. 215.

N.B.—All the counts given here apply to warp and not weft.

It will be seen that in the majority of instances, a distinct advance in the value of cotton has been gained by

selection and if only ginning percentages and acreage outturns had been available, a rigid estimate could have been framed of the actual value of all the cottons which have been examined.

Burma. Mr. McKerral reports as follows:—

"The cottons received from you were grown at the Agricultural Station at Tatkon, Yamethin District, Burma. The year was rather wet and the cotton crop in general on this farm was not very successful. None of the Indian short-lived cottons were a success and they did not appear to do as well as the Burmese 'Wa-gale' (*G. neglectum*), which was grown alongside of them. The same was true of the long-lived types and Broach cotton proved a complete failure, while Burmese 'Wa-gyi' (*G. obtusifolium*) gave a fairly good crop although it flowered late. I conclude that our best chances of improving cotton in Burma will be to undertake selection for yield and ginning percentage with the indigenous varieties. I have, however, retained small cultures of all the cottons sent by you.

"With regard to the Burmese cottons, it was found that 'Wa-gale' (*G. neglectum*) which is our short-lived kind, consists of three well-marked botanical types (1) a yellow-flowered type, (2) a white-flowered. This occurs in small proportion in the ordinary crop and appears to be the type called by you 'Avena,' (3) a type showing reddish coloration of the petioles, leaves, bracteoles, etc., and possessing a longer and finer staple than the other types. This was found in samples received from the Shan States and looked a promising type. Unfortunately, however, its ginning percentage has been found to be very small. The white-flowered type appears to have the highest ginning percentage and in

the case of one single plant this appeared to reach 40 per cent. The white-flowered variety is being separated from the yellow and a large number of single plant selections of all three kinds have been made. No markedly different types have been observed so far in 'Wa-gyi' (the long-lived Burma cotton) and the crop appears to be fairly uniform. Further observations, however, are being made this year."

As in former years, I have to thank Messrs. Tata, Sons & Co., for the trouble they have taken in furnishing valuations of the numerous samples of cotton submitted to them.

III. Programme of work for the year 1915-16.

(1) To visit and advise on points regarding cotton and its cultivation whenever requested to do so by the Provincial Departments of Agriculture.

(2) The study of the behaviour of Bourbon, Bhuri, Cambodia and other such cottons in non-cotton-producing tracts, as detailed in the last year's programme, will be continued.

(3) An enquiry on the manurial requirements of cotton will be continued.

(4) Researches on the botany of cotton will be continued.

REPORT

OF THE

Agricultural Research Institute and College, Pusa

(Including the Report of the Imperial Cotton Specialist)

1915-16

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1916

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Report of the Agricultural Research Institute and College, Pusa

(*Including the Report of the Imperial Cotton Specialist*)

1915-16.

REPORT OF THE DIRECTOR.

(J. MACKENNA, M.A., I.C.S.)

I. CHARGE AND STAFF.

Charge. I succeeded Mr. B. Coventry, C.I.E., as Agricultural Adviser to the Government of India and Director, Agricultural Research Institute, Pusa, on the 1st April 1916, when he retired from the service of Government. Mr. Coventry has been identified with the Institute since its foundation and has been responsible for its development and growth. It is now one of the best equipped establishments of the kind in the East. Mr. Wynne Sayer was Assistant to the Agricultural Adviser throughout the year.

Staff. The following changes in staff took place during the year.

Mr. J. W. Leather, V.D., F.I.C., Imperial Agricultural Chemist, proceeded on combined leave from 16th September 1915, preparatory to retirement. He has since joined a Garrison Battalion of the Cheshire Regiment as a Major. Mr. Jatindra Nath Sen, M.A., F.C.S., Supernumerary Agricultural Chemist, was appointed to act as Imperial Agricultural Chemist.

Mr. A. Howard, C.I.E., M.A., and Mrs. Gabrielle L. C. Howard, M.A., the Imperial Economic Botanists, took one month's privilege leave from 10th November 1915.

Mr. E. J. Butler, M.B., Imperial Mycologist, returned from leave on the 16th November 1915, and resumed charge of the section from Mr. F. J. F. Shaw, B.Sc., A.R.C.S., who had been officiating.

Mr. T. Bainbrigge Fletcher, F.L.S., F.E.S., F.Z.S., Imperial Entomologist, held charge also of the duties of the Imperial Pathological Entomologist from the 9th August 1915, in place of Mr. F. M. Howlett, B.A., F.E.S., Imperial Pathological Entomologist, on leave.

Mr. C. M. Hutchinson, B.A., Imperial Agricultural Bacteriologist, was on privilege leave for one month from 7th September 1915.

The Agricultural Section was in charge of Mr. S. Milligan, M.A., B.Sc., up to 2nd June 1916, when he was transferred to Bengal as Officiating Director of Agriculture and Mr. G. S. Henderson, N.D.A., N.D.D., was appointed to officiate as Imperial Agriculturist.

Mr. W. A. Davis, B.Sc., A.C.G.I., F.C.S., was appointed to the special post of Indigo Research Chemist, and posted to Pusa. He joined his appointment on the 20th May 1916.

II. Work of the Institute.

Scientific work. The scientific work of the Institute during the year is indicated in the reports of the various sections.

Training. The training of students in post-graduate courses was continued and short courses were also given in cattle management and sericulture.

In the section of Agricultural Bacteriology two students completed their course during the year under report and returned to their respective Provinces. An Assistant deputed by the Assam Department of Agriculture is now under training.

In the Botanical Section an Assistant deputed by the Burma Department of Agriculture was trained during the year in work connected with wheat-growing.

In General Entomology two students completed their training and at the end of the year under report one agricultural graduate is taking this course.

In the Mycological Section, two students completed their course during the year.

An Assistant deputed by the United Provinces Department of Agriculture is undergoing training in general agriculture in the Agricultural Section.

Besides the regular students referred to above the following visitors also worked in the laboratories :—

Mr. Karm Chand Mehta, M.Sc., Professor of Botany, Agra College, and Mr. Bamanji Nowroji Vakil, B.Sc., of Bombay, worked in the Mycological Laboratory from 3rd March to 27th March 1916, and 15th March to 25th April 1916, respectively. Mr. Mahdi Hasan, a private student from Hyderabad, Deccan, worked in the Entomological Laboratory for about four months. Mr. Deoki Nandan, M.R.A.C., took a course in general agriculture, mycology and entomology.

Three students took the short course in sericulture and a graduate of the Lyallpur Agricultural College took the special course in cattle breeding and dairying.

III. Publications.

The Agricultural Journal of India, Scientific Memoirs and Bulletins continued to be issued during the year. The Department published during the year 13 Memoirs and 6 Bulletins; 6 Memoirs and 4 Bulletins are in the press. The Proceedings of the Inter-Provincial Jute Conference (1915) and of the 9th Meeting of the Board of Agriculture in India (1916), were also issued during the year. A Bengali version of Bulletin No. 48, has been published and copies

distributed free in the important silk centres of Bengal. A revised edition of the Manual of More Deadly Forms of Cattle Disease in India was also published during the year. A special number of the Agricultural Journal of India was issued including all papers of agricultural interest read at the Third Indian Science Congress held at Lucknow in January 1916. A revised edition of Bulletin No. 39 and the second edition of Bulletins Nos. 52 and 53, are in the press. The grant of Rs. 29,000 permanently sanctioned for publications was continued during the year under report. Owing to the continued rise in the prices of paper and other materials, strictest economy had to be exercised to keep down the expenditure within the sanctioned limits.

IV. General Administration.

Buildings and Works. During the year under report four additional quarters for the subordinate staff were completed and four more quarters are under construction. The female ward for the Pusa Hospital was also completed during the year. Necessary funds have been allotted for the installation of electric lights and fans in the European bungalows and the work is in the hands of the Public Works Department. The new ice machine referred to in last year's report has been installed. Several minor works were also done during the year out of the grant of Rs. 5,000 placed at my disposal in the civil works budget of the Public Works Department.

Library. The third edition of the catalogue of the Pusa Library, was issued during the year. In addition to the foreign bulletins, memoirs, reports, etc., which are received in exchange from different parts of the world, over 300 volumes were purchased for the library during the year.

Pusa Schools. The number of pupils attending the Pusa High School at the close of the year was 185. In March 1916, the school sent up seven boys for the Matriculation Examination of the Calcutta University and of

these five passed in the first division and one in the second division.

The Lower Primary Girls' School remained closed during the greater part of the year on account of the death of the mistress of the school. It is hoped that the vacancy will soon be filled as there is a demand for female education

General Health of the Station. The general health of the station during the year under report was satisfactory. Relief was afforded to 10,458 persons at the Pusa Hospital, of which 10,223 were treated in the out-patients department and 235 in the indoor department.

The average daily attendance was 68·07 in the out-door and 12·01 in the indoor departments.

The total number of deaths in the hospital were 11. Most of these cases were brought to the hospital in rather advanced stages of illness.

Occasional outbreaks of cholera in the villages lying in the immediate vicinity of Pusa during the months of September, November and December 1915, became a source of great danger to the Estate. Preventive measures were promptly taken, and the wells were thoroughly disinfected with the result that the disease did not enter the Estate.

Thirty-two primary and eight re-vaccinations were done during the year.

V. Accounts.

The total expenditure during the financial year 1915-16 was Rs. 4,63,817, as under :—

	Rs.
Office of the Agricultural Adviser to the Government of India and Director of the Institute	2,00,852
Chemical Section	31,699
Mycological Section	32,231
Entomological Section	41,297
Pathological Entomological Section	16,728
Botanical Section	43,803
Bacteriological Section	28,436
Agricultural Section	68,771
Total	4,63,817

In addition to the above a sum of Rs. 23,502 was spent out of the provision of Rs. 23,560 made under " Sugar Experiments " in the budget of this Department for 1915-16, in connection with the engagement of Mr. W. Hulme as Sugar Engineer in the United Provinces.

A sum of Rs. 15,000 was paid as a grant-in-aid to the Indian Tea Association.

The principal items of expenditure under the annual grant of Rs. 10,000 placed at the disposal of the Agricultural Adviser to the Government of India for special Agricultural Experiments were as follows :—

	Rs.
Purchase of a small sugarcane crushing plant required for experiment by the Agricultural Chemist, United Provinces . .	500
Cost of additional machinery for sugar plant required by Mr. Hulme	6,000
Purchase of silk yarn for sericulture experiments at Pusa	194
Experimental cotton cultivation conducted by the Imperial Cotton Specialist . .	1,500
Pay of a Veterinary Assistant in connection with cattle breeding and of a Fieldman for mosquito experiments	863

The gross receipts during the year from the sale of farm produce, milk, publications of this Department and other articles amounted to Rs. 15,340 as against Rs. 16,843, in the previous year.

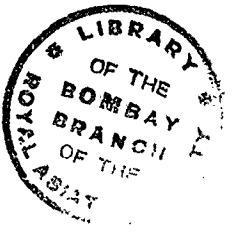
VI. Conferences.

An informal conference on the subject of Agricultural Education was held at Pusa on the 4th and 5th February, 1916, under the presidency of the Hon'ble Mr. C. H. A. Hill, C.S.I., C.I.E., I.C.S. It was composed of officials of the Agricultural and Education Departments, Mr. Fremantle, Collector of Allahabad, one non-official member and myself. The ninth meeting of the Board of Agriculture in India was also held at Pusa in the same month. It was attended by 47 members and 24 visitors and was pre-

sided over by Mr. Coventry. The arrangements were made by Mr. Wynne Sayer, Assistant to the Agricultural Adviser to the Government of India, who also acted as Secretary to the Board.

VII. Visitors.

His Honour the Lieutenant-Governor of Bihar and Orissa, visited the Institute on 6th August 1915. During the year under report the Hon'ble Mr. C. H. A. Hill, C.S.I., C.I.E., I.C.S., Member-in-Charge of the Department of Revenue and Agriculture, the Hon'ble Mr. R. A. Mant, I.C.S., Secretary to the Government of India, Department of Revenue and Agriculture, Mr. Van Geuns, Editor of the *Soerabajasch Handelsblad*, Java, and others visited the Institute.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REPORT OF THE IMPERIAL AGRICULTURIST.

(G. S. HENDERSON, N.D.A., N.D.D.)

I. ADMINISTRATION AND TOURS.

Mr. Milligan held charge of the post till the 2nd June 1916, and then handed over charge to me on his being appointed to the post of Director of Agriculture, Bengal.

The senior members of the staff remained practically unchanged. An appreciative note was left by Mr. Milligan of their services.

Mr. L. S. Joseph acted for Mr. Judah Hyam, Veterinary Overseer, for a month and then volunteered for military duty, on the transport of horses to Egypt, for two months. He again volunteered for military duty and went to Mesopotamia on the 6th July 1916.

Tours. Mr. Milligan examined students at the Cawnpore Agricultural College in September 1915, also visited Hoshangabad and Panna State in Central Provinces and the Kamrup sugarcane estate in Assam in January.

II. TRAINING.

There were during the year under report three students, post-graduates, who got a practical insight into the working of the farm and the details of steam cultivation.

III. FARM CULTIVATION.

The rainfall was 51·37 inches as compared with 54·88″ last season. Heavy rains fell in August and the new 18″ drainage pump was working during most of the month. It cleared the stagnant water in a satisfactory fashion. The October rains were poor.

Cropping. The major portion of the farm is cropped for the purpose of feeding the breeding herd, work cattle, etc. The stock at Pusa averages about 430 head, this requires an enormous amount of stuff. In one day 100 maunds of green fodder, 25 maunds of oat straw and 17

maunds of grain are supplied. When the seasons for green fodder and silage are finished, over two tons per day of oat straw are needed. Fifteen thousand maunds of silage were used during the year.

In the past season there were 280 acres of land double cropped, mostly maize in kharif, sown with *arhar* (*Cajanus indicus*) reaped in rabi, or maize followed by cats in rabi. 147 acres were single cropped. The area of crops was over 700 acres. Fallows were 120 acres.

In addition to the oats, maize and *arhar* supplied as concentrated food, seed has to be kept for the next season. The budget, buildings and equipment are all insufficient for the area cultivated. Bamboo *kutcha* sheds have to take the place of more permanent structures. The roofs of the breeding herd buildings, a part of the old horse breeding establishment, are in a precarious condition. A mile or two of light tramway would facilitate the working of the estate.

The set of steam tackle (Fowler's double engine, K. class, single cylinder) worked 254 days and the following work was done :—

Ploughing with disc plough	260	acres.
Disc harrow	1,549	„
Grubber	735	„
Roller	529	„
Zig-zag harrow	195	„

The best work in one day for each operation was 7 acres ploughed, 22 acres harrowed, 18 acres grubbed, and 27 acres rolled.

All crops were drilled and then from time to time intercultured with Wallace's horse hoe and hand weeding was reduced to a minimum.

Crop Experiments. About 20 acres of sugarcane were grown without any irrigation; 6,639 maunds of cane were sold to a factory.

The series of permanent rotational and cropping experiments were continued.

A series of green manurial experiments in conjunction with the Imperial Agricultural Bacteriologist was continued.

The new experiment field is being tested uniformly with oats in order to select plots of similar output.

The *rabi* crop of oats all over the farm was exceptionally good. In the weighed plots the best yields were, wheat 30 maunds per acre, oats 39 maunds per acre and barley 24 maunds; the total yields of grain exceeded the last year's yield by over 1,600 maunds.

IV. Live-Stock.

Cattle Breeding. Two herds are being kept at Pusa, one of selected Sanhiwal (Montgomery) cows and their descendants and the other of cross-bred Ayrshire-Sanhiwal cattle. From want of ground and buildings, however, both herds are kept together. There are 7 bulls, 2 Ayrshire bulls (Carston Royal Scotch and Lessnessock Wildfire), 107 cows, 59 bull calves, 103 cow calves and 25 young cross-bred stock.

In the pure bred herd 4,000 lb. of milk in a lactation period has been accepted as the standard, anything less will fail to qualify for admission. The herd is kept in 5 groups with a separate bull for each group, this will enable the herd to be carried on for a considerable time without outside blood.

Among the cross-breds the heifers produced by the first Ayrshire bull "Mossgeil Titanic" (now dead) will be crossed by the produce of "Lessnessock Wildfire."

During the year there were on a daily average 119 customers for milk, the average number of cows in milk was 55, and the average daily yield of milk was 35 gallons including the milk taken by the calves.

Two cows, Mookhia and Roopiria, each produced over 490 gallons.

Nine animals were sold from the herd for breeding purposes at nominal rates to approved breeders.

Sheep Breeding. Operations have been continued as described in last year's report. The sheep now number 211 head.

V. General.

Drainage. The new bund round the south of the estate was completed and a number of drains in the Brickfield and other low places were dug. The drainage system is very complete now and with the exception of two fields which are outside the scheme any ordinary flooding can be dealt with expeditiously.

Levelling. Some levelling was done with bullock scrapers but nearly all fields still require some low places filled up.

A new 4 feet 6 inches threshing machine was used for threshing the oats, etc. The best day's work was just under 400 maunds of cleaned oats.

VI. Programme of work for 1916-17.

The following are the lines of work in progress :—

Major investigations.

1. Economics of cultivation of steam engines.
2. Investigation of most suitable rotation and manuring for land devoted to cattle feeding.
3. Trials of various leguminous fodder crops.
4. Study of inheritance of characters of dairy cattle by crossing.
5. Building up of milk pedigree in cattle by selection.
6. Manurial experiments with fermented green manures in collaboration with the Imperial Agricultural Bacteriologist.

Minor investigations.

7. Inheritance of wool characters in sheep.
8. Experimental tillage in growing of maize and sugarcane.
9. Improvement of pastures.

REPORT OF THE IMPERIAL AGRICULTURAL CHEMIST.

(J. SEN, M.A., F.C.S.)

I. ADMINISTRATION AND TOURS.

Charge. The section was in charge of Mr. (now Major) J. W. Leather, V.D., F.I.C., up to the 15th September 1915 when he proceeded on long leave preparatory to retirement. He has since joined the 3rd Battalion, Cheshire Regiment. The First Assistant was in charge of the current duties from 16th September to 6th November 1915 when I took over charge of the section as Officiating Imperial Agricultural Chemist.

Establishment. Mr. P. N. Mehta, B.A., was appointed an assistant on 10th July 1915.

Mr. B. M. Amin, the Third Assistant, has been deputed to work under the Indigo Research Chemist with effect from the 15th June 1916.

Babu Upendra Nath Sen Gupta, B.A., was appointed a probationary assistant from the 15th June 1916.

Tours. Major Leather visited Simla in July to confer with the Commissioner of Northern India Salt Revenue about the experiments on refining saltpetre and also went to Cawnpore in September to arrange about draingauge work.

I went to Sabour in December to see to the harvesting of my experimental plot of paddy there.

II. EDUCATION.

Babu Upendra Nath Sen Gupta joined this section as a private student but has afterwards taken up appointment as an assistant.

III. METEOROLOGY AND DRAINGAUGES.

In addition to the usual records for the Meteorological Department, records of atmospheric pressure by means of a

barograph have been maintained. Work in connection with draingauges here is being kept up. The waters and crops from the Cawnpore draingauges are also being analysed as usual.

IV. Infertility under trees.

The problem of the occurrence of infertile patches in the soils under trees is being studied. It has been found that in many cases, though not in all, this is associated with a decreased permeability of the soils and the presence of soluble salts.

V. Rice.

The Rices of Bihar and Orissa. In view of the importance of a chemical study of this valuable food crop the examination of the composition of the rices grown in Bihar and Orissa was undertaken, along with other related questions of interest.

It was thought desirable to confine the work to samples of rice in the Government farms, where they are grown under definite cultural conditions. The rices were, however, not pure line cultures. Of the samples received, three came from Bankipore, one from Bettiah, three from Cuttack, thirteen from Dumraon and five from Sabour. The samples studied did not include any *boro* rice.

Composition of the Rices. The composition of the rices did not vary much.

The analytical figures allow an interesting deduction. The amounts of oil, fibre and ash vary between very narrow limits and the sum of these constituents will be more or less constant. The sum total of the remaining constituents of albuminoids and soluble carbohydrates is thus also constant. It was found that the sum of the percentage figures for albuminoids and soluble carbohydrates, in all instances except three, fell between 94 and 95. In these three latter cases the figures were 93·9 and 95·3. But the deviation is so small that the general observation may be said to hold good in these instances also. It was thus noted that when

the amount of albuminoids was high the carbohydrate content was low and *vice versâ*.

The amount of phosphoric acid is always very slightly less than half of the total mineral matter present. Potash is, again, very nearly half of the amount of phosphoric acid present.

The effect of polishing. The composition of polished rice is dependent somewhat on that of the original unhusked rice. But although the amount of substance removed as bran is not very much, the grain suffers a material alteration in composition. The polished rice becomes poorer in all constituents except soluble carbohydrates which increase a little. The amount of oil decreases to less than half; the albuminoids suffer only a slight diminution; the fibre is reduced to about one-fourth of the original quantity and the amount of mineral constituents falls to a half. The outer layer and the embryo which are removed during the polishing operation are thus seen to be richer than the inner material in all these constituents. But the concentrations of fibre and oil in the bran are relatively higher than that of the mineral constituents. The distribution of the albuminoids is more uniform than that of any of the above.

It has been noted already that in the unpolished grain the quantity of phosphoric acid is just less than half of the ash. In the polished rice also, the phosphoric acid is slightly less than half of the amount of ash. The potash content, however, which in the unpolished rice is about half of that of the phosphoric acid now rises to about three-fourth of the amount of phosphoric acid.

It thus amounts to this that, although both phosphoric acid and potash are more concentrated in the " bran " than in the rest of the seed, the distribution of the potash is more uniform than that of the phosphoric acid.

As regards the material lost during the operation of polishing, this consists of the plant embryo and some of the outer layers of the grain. The germ being freely exposed and not embedded in the grain is easily rubbed off, the little

nick at one end of the polished grain marking the place where it was located.

Rice as an article of diet. It might be supposed that the estimation in which any variety of rice is held among the consumers, as evidenced by its market price, would be mainly determined by its nutritive value and its palatibility. The latter term includes culinary properties, such as flavour, consistence. appearance, taste, etc., which cannot be definitely described and are rather difficult to observe accurately.

As regards the nutritive value of rice, as revealed by analysis, there is no doubt that, other things being equal, the variety of rice which contains larger amounts of albuminoids is more valuable, inasmuch as albuminoids, which are the flesh formers, are a more expensive form of food than starch. The relative nutritive value of a sample of rice can thus be assumed to depend on its albuminoid content. It was noticed, however, that no accurate relation can be found between the chemical composition and the value of a rice from the consumer's point of view.

In a well-balanced ration, the relations between the albuminoids, the oil and the soluble carbohydrates should vary within certain definite limits. Rice, however, in common with other cereals, contains an excessive proportion of starch and is thus not suitable for use as the sole article of diet by any one.

This holds not only from the point of view of the organic constituents but also of the mineral ones, which are the bone-formers. Rice is quite poor in this respect also. The importance of giving due consideration to the amount and composition of the ash of foods is very great in order to ensure the supply of material for the proper development of bone, and of the mineral constituents necessary for vital processes—factors which have as much influence on the well-being of animals as proteids, carbohydrates and fats in appropriate quantities.

Where a variety of food stuff is used, the probability of much injury being done by ignoring these aspects of the

question is not very great. Happily the use of rice is nearly always supplemented by the addition of other substances of vegetable and animal origin which often supply the deficient elements.

An interesting characteristic of rice protein may be mentioned here. It has recently been shown that in its general aminoacid make-up the protein of rice more nearly resembles the majority of the proteins of animal tissues than do the proteins of maize and wheat. This may explain the fact that rice, in spite of its low protein content, furnishes food for more human beings than any other cereal.

The alteration in composition which rice undergoes during the process of polishing is of great significance from the medical point of view. Some authorities believe that beri-beri is due to specific germs. Others think that it is caused by the bacterial fermentation of the large amounts of carbohydrates eaten in unbalanced diet. But the consensus of opinion is that beri-beri is one of the " deficiency diseases " like, *e.g.*, scurvy or rickets. Most of the food articles in their raw state contain the curative substances. These are, however, at times lost, or considerably reduced, during the process of " finishing " and preparation which the fastidious taste of the modern consumer prescribes. Reduction in the content of phosphoric acid is now generally accepted as an index of the beri-beri-producing power of a sample of rice. Judged by this standard, although all samples of unhusked rice used during this investigation were good, many samples of the " polished " rice were unfit for consumption as a sole article of diet. It must be remembered, however, that rice is almost universally supplemented by some other foodstuffs, the mixed diet often to a great extent nullifying much of the apprehended injurious effects.

Assimilation of nutrients by the plant. The proper supply of nutritive elements is an important factor in the growth of a plant and, in view of the economic importance of the rice crop, a study was made of the assimilation of the nutrient materials by this plant at various stages of its growth.

For conducting these experiments a uniform plot of rice land was chosen at the Sabour Farm. The seed employed was "kalamdan" which is at present the standard medium aman paddy of the Sabour Farm. It was originally derived from pure culture and its purity was maintained, as far as is possible under field conditions, by rogueing every year.

In order to do away with the disturbing factors consequent on transplanting, it was decided to allow the rice to grow to maturity in the same field where it was sown. After the usual cultivations, the seeds were sown in the third week of May, by dibbling in plough furrows and afterwards covering them up by beaming. Weeding was done when required. The plot had to be irrigated once in August.

Samples of plants (the exact number of plants varying according to the size) were selected in such a way as to fairly represent the whole crop. It was not possible to take out the whole root system but care was taken not to lose much of the roots. After the soil adhering to the roots had been washed out the plants were divided into their botanical parts and analysed. The following samples were taken :— (1) very young seedlings, (2) at the transplantation stage, (3) at preflowering stage, (4) at the flowering stage (two samples, one in which the grain was in the "water" stage, and another in which it was beginning to form "milk"), (5) at the ripe or ordinary harvest stage and (6) when the crop was dead ripe. The results obtained need not be entered here in detail but some of the points observed may be mentioned.

1. The total dry matter in a rice plant increases up to the time of maturity, the largest increase in the weight of the crop occurring before the formation of the flowers.

2. The percentage of nitrogen generally exhibits a steady and continuous decrease from the first to the last period of growth, the most rapid decline being noted in the second period. The above-ground parts are always richer than the roots in their nitrogen content. At the ear-

lier stages the leaves are practically twice as rich in this element as the stems. As the ears form, both the stems and the leaves lose nitrogen. By the time that the grains " fill up " the nitrogen accumulates most in the grain while in the other parts of the plant it falls to the uniform level of about a third of what is present in the grains. It seems therefore that there is a tendency for the nitrogenous matter to press forward towards the top of the plant.

3. The configuration of the curve of the content of phosphoric acid at the different stages indicates that the amount of this plant food available for the rice plant at Sabour was low throughout.

4. The percentage of potash in the above-ground parts increases from the first stage to the preflowering stage from whenceforward there is a decline. In the roots also there is a continued fall after the second stage.

5. As the ears form and mature there occurs a concentration of nitrogen, phosphoric acid and potash in the grains at the expense of the other parts of the plant.

6. The assimilation of nitrogen, phosphoric acid and potash by the plant is fairly complete by the time flowers appear. Hence enough plant foods must be available for the plant during the early stages.

7. There does not seem to be any migration of the absorbed nitrogen and potash back into the soil.

8. Taking the yield of a crop of rice as 900 lb. of dry grain, the soil suffers a depletion of 29·33 lb. nitrogen, 9·64 lb. phosphoric acid and 49·69 lb. potash per acre by the removal of the grains and straw.

Feeding value of the different parts. As to the feeding values of the different parts of the rice plant, as calculated from the chemical analysis at the various stages, it was found that the straw declines in value with the age of the plant but there is no difference in nutritive value between ripe and dead ripe plants. The leaves are more nutritious than the stems of the same period. The leaves in the preflowering and the flowering stages are about

equally nutritious but decline considerably in value as the plant matures.

VI. Feeding Stuffs (General).

A considerable number of samples of feeding stuffs have been analysed, the greatest number being, as in last year, from the Military Department. It is intended to issue a bulletin incorporating the results of these and other analyses.

VII. Starch.

The experiments begun last year in connection with sweet potato as a possible source for the commercial production of starch, have been continued.

In order to find out the yield and quality of starch at different periods of growth, fortnightly harvests were made from a field of sweet potatoes, from the latter half of January to the end of March. The analysis showed that the best time for harvesting the crop was the middle of February.

Through the kindness of the Imperial Agriculturist arrangements are being made to grow different varieties of sweet potato in a plot of land better suited to this crop.

Another crop tested was the kidney-shaped yam, *Dioscorea fasciculata* (vern. *suthni*) which also is largely grown here. One sample was found to contain 19 per cent. of starch, and to yield a very good quality of starch.

VIII. Lathyrus sativus.

An attempt was made to find out the poisonous constituent of *Lathyrus sativus* (vern. *khesari*) which has a bad reputation for causing paralysis. Samples of this pulse grown at Pusa and at Barail (a village 8 miles from Pusa which is notorious for cases of lathyrism) as well as some samples from the Central Provinces (where also bad cases of the disease occur) were examined. No alkaloids were detected although some of the previous workers had found what seemed to be a volatile alkaloid.

During the course of this work it was found that *khesari* samples are very often contaminated with foreign seeds from which a cyanogenetic glucoside was isolated and some feeding experiments were conducted with guinea pigs. These seeds were identified as *Vicia sativa* (vern. *akta*) and *Vicia hirsuta* (vern. *misia*). As the chemistry of these grains had been worked out by Ritthausen, further investigation was abandoned.

IX. Relation of Transpiration Ratio and absorption of food materials.

Pot culture experiments were started during the year to ascertain the relation between the transpiration of water and the assimilation of plant food at different stages of the plant's growth. The following crops were sown :—Maize, velvet bean, *rahar* and *marua* in the *kharif* and *sarson*, wheat and gram in the *rabi*.

The soil employed was Pusa soil and received an application of superphosphate and potassium nitrate. The moisture content of the soil was maintained at 20 per cent. and the transpiration was daily measured. At regular intervals the plants from the jars were harvested and analysed for nitrogen, phosphoric acid and potash.

Some interesting results have been obtained but results of further experiments are awaited before definite conclusions could be justified.

X. Programme of work for 1916-17.

Major subjects :—

1. Records of the amount and nature of drainage water from fallow land, and land bearing crops, will be maintained.

2. The relation between the transpiration of water by plant and the assimilation of plant material during the period of growth will be further studied.

3. An examination of the proportion of starch in some of the Indian starch-producing crops will be made with a

view to their possible utility as commercial sources for the manufacture of starch.

Minor subjects :—

1. The assimilation of plant material by the rice plant will be further studied.

2. The problem of the occurrence of infertility under trees will be examined.

XI. Publications.

The following papers were published during the year :—

(1) Leather, J. W. . Soil Temperatures. *Mem. Dept. of Agri., India (Chemical Series)*, Vol. IV, No. 2.

(2) Leather, J. W. . Soil Gases. *Mem. Dept. of Agri., India (Chemical Series)*, Vol. IV, No. 3.

(3) Leather, J. W. . The Detection of Added Water in Milk in India. *Bulletin 57, Agricultural Research Institute, Pusa.*

(4) Sen, J. . . A Preliminary Chemical Study of the Rices of Bihar and Orissa. *Bulletin 62, Agricultural Research Institute, Pusa.*

(5) Sen, J. . . A study in the assimilation of nutrients by the rice plant. *Bulletin 65 of the Agricultural Research Institute, Pusa.*

REPORT OF THE IMPERIAL ECONOMIC BOTANISTS.

(A. HOWARD, C.I.E., M.A., AND GABRIELLE L. C. HOWARD, M.A.)

I. INTRODUCTION.

The Imperial Economic Botanist held charge of the section during the year with the exception of one month (November 10th—December 9th, 1915), when privilege leave was taken in India. The Second Assistant was in charge of current duties at Pusa during this period and the Third Assistant was placed in similar charge at Quetta. Both of these assistants acted up to the level of their responsibilities.

The work of the staff during the year was quite satisfactory. Babu Kashi Ram was appointed to the post of Fourth Assistant on transfer from the Saharanpur Botanical Gardens and has made a good beginning in his work. This opportunity is taken of acknowledging the valuable assistance given by Mr. Hartless, the Superintendent of the Saharanpur Gardens, in training men for work in the Botanical Section at Pusa and also at the Fruit Experiment Station at Quetta. Babu Chandu Lall has improved in his work at Quetta and has been confirmed and promoted by the Baluchistan Administration.

One student from Burma worked in the section during the cold weather.

Mr. Jatindra Nath Sen, officiating Imperial Agricultural Chemist, has carried out a good many analyses for the section which have proved of considerable use in our investigations.

II. INVESTIGATIONS AT PUSA.

Wheat.

Pusa 12. While a beginning has been made in several Provinces in distributing this wheat to cultivators, these efforts are of minor importance compared with the schemes

in progress in the United Provinces where the Agricultural Department, during the past year, has made considerable progress in the systematic replacement of the country wheats by this improved type. The trial of Pusa 12 in these Provinces has passed the experimental stage and the time is rapidly approaching when it will be possible to see large continuous blocks of this variety true to type. At first, progress was greatly hampered by a shortage of seed but with an increasing supply and with larger funds for financing the operations, these preliminary difficulties are being overcome. A feature of the work of seed distribution in the United Provinces is the manner in which all the existing agencies have been utilized. In the Central Circle, the Co-operative movement has largely been employed in addition to Court of Wards' estates and large zamindars. In Oudh, an entirely new agency has been brought into use by Mr. Sharma, namely, the local notables, who, in a sense, are large and wealthy Co-operative Societies ready-made commanding great influence with the cultivators. Anyone who has seen the work in progress with Pusa 12 on some of the large private estates in Oudh cannot fail to be impressed by the immense possibilities of this new departure. Improved agriculture on these estates has been found to be very profitable and the new private seed farms, such as those personally conducted by the Raja of Amethi and the Kunwar Sahib, are proving of great value to the Agricultural Department in the replacement of the local wheats by Pusa 12.

Like the season of 1913-14, the year in the United Provinces was characterized by a shortage of moisture, particularly in the Western Districts. Pusa 12 again withstood satisfactorily these adverse conditions and its behaviour, as compared with the country wheats, was summed up as follows by the Director of Agriculture in "United Provinces Agricultural Notes" for March and April 1916 :—

"Pusa 12 wheat has again proved markedly superior to the Provincial wheats, and is likely to go ahead rapidly over the western and central portions of the provinces.

Apart from its qualities of yield, it requires less water than the best local varieties, such as Muzaffarnagar, and is likely to take the place of the latter in the canal tracts owing to recurrent shortages of the water. In one of the private estates in Oudh in which there are 75 acres under this wheat, the crop, which is being threshed out by the Department, has given an average of 25 maunds of grain and 45 of *bhusa* per acre." (*Pioneer*, April 9th, 1916.)

" Figures have been received from Co-operative Societies as to the relative yield of Pusa 12 and *deshi* wheat. In two neighbouring societies, in the Central Circle, the average yield of Pusa 12 was 19 maunds per acre and of *deshi* 16¼ maunds. The former wheat stood the test of a dry season satisfactorily. Crop cutting experiments were carried out in fields where only one irrigation was possible; and the yield of Pusa wheat was 17 maunds as compared to 14¼ from *deshi*. On an average, the former wheat yielded substantially more *bhusa*." (*Pioneer*, April 8th, 1916.)

These results enable a rough estimate to be formed of the annual increase in value of the crop which will be obtained when the whole of the wheat-growing area of the United Provinces is replaced by Pusa 12 or some similar improved type. As far as yield of grain and *bhusa* are concerned, the increased production due to Pusa 12 comes to over twelve rupees an acre. If the improved grain quality is estimated at three annas a maund and if the average production is put at sixteen maunds to the acre, the increase in the value of the crop from this cause would be three rupees an acre. Considering that Pusa 12 already commands a premium of more than four annas a maund in the local bazaar, the above estimate is well within the truth. If, therefore, we take into consideration both yield and quality, the substitution of the country wheats by Pusa 12 means an immediate average increase of fifteen rupees an acre or £7,000,000 per annum for the whole of the United Provinces.

While the local transactions in Indian wheat are considerably more important than the export trade, neverthe-

less the latter is well worthy of consideration even under the present conditions of production. If, however, an increase in yield is brought about by changing the variety or by better methods of cultivation, the surplus left over for export will increase and India will then take a larger share in the wheat production of the Empire. There can be little doubt that such a result is easily possible. At present, the great plains of India do not produce half of what is possible. With a few simple improvements, the alluvial soils of India could be made to grow twice their present crops and the Punjab and the United Provinces would then become the most important bread-basket of the Empire. Wheat-growing is at present one of the great neglected and undeveloped natural industries of India. The capital for expansion is lying ready to hand in the shape of a marvellously fertile soil when properly managed, while in the cultivator and in his oxen is the foundation of the labour force necessary for development.

In consequence of the extension of indigo cultivation in Bihar, the area of Pusa 12 put down for seed on the estates was considerably restricted. In spite of the high prices of indigo, over 3,000 maunds of seed of this type were supplied to Mr. Burt for distribution in the United Provinces.

Pusa 4. The circumstances of soil and climate in some of the wheat-growing tracts of India are such that a rapidly maturing variety is one of the conditions of progress. In tracts like Bundelkhand, some of the Central India States, the southern portions of the Bombay Presidency and parts of Bihar, a wheat is required which can ripen quickly with a short supply of moisture and which can also resist the early rusts. In such tracts, deep-rooting, high-yielding kinds are useless and producing power has to give place to the insurance of the yield in years of average soil moisture. In such areas, Pusa 4 is giving good results and is being taken up by the cultivators. The demand for seed is increasing and for several years to come the surplus produce from the indigo estates in Bihar is likely to continue to find a ready market. Pusa 4 is a large-grained, attractive-looking wheat which at once finds favour with the cultiva-

tors and in the bazaar on account of its grain quality and the high percentage of flour it yields.

During the year, a complete milling and baking test of this variety was carried out at the Hooghly Flour Mills, Calcutta, managed by Messrs. Shaw, Wallace & Co. The sample milled was 350 maunds in weight and was grown as a cover crop for Java indigo on the Dholi and Benipore estates in Bihar. The report, which will be published in due course, is an exceedingly favourable one. The wheat behaved in the mill exactly as would be expected from Mr. Humphries' reports on maund samples in England while the loaves were much superior to those produced from the best Calcutta flour.

Pusa 4 is doing very well in New South Wales. A large sample, grown at Gilgandra from seed supplied from Pusa, took the first prize at the recent Royal Agricultural Show at Sydney. This prize has formerly been obtained by one or other of the wheats produced by the late Mr. William Farrer. Both in appearance, bushel weight and in the milling tests, Pusa 4 proved superior to any of the new varieties produced in New South Wales.

The demand for seed of Pusa 4 increased considerably during the past year. In addition to numerous small consignments, about 1,500 maunds were supplied from Bihar estates to Mr. Burt, in connection with his seed distribution scheme in Bundelkhand. As usual, a large number of indents were received after the available supply had been disposed of. There seems to be an exaggerated idea in India as to the resources of the Botanical Section at Pusa both as regards storehouse accommodation and as regards funds. Neither Pusa nor the Bihar indigo estates, which grow wheat for seed, are in a position financially to warehouse large quantities of seed wheat during the monsoon. All wheat, except for seed, has to be distributed at harvest time, a fact which correspondents should carefully bear in mind.

Shipments of Pusa 12 and Pusa 4 to England. In the last annual report, mention was made of a small prelimi-

nary shipment of Pusa 12 to England. This side of the wheat investigations, which is being conducted in co-operation with Mr. B. C. Burt, Deputy Director of Agriculture, Central Circle, United Provinces, has developed rapidly during the past wheat-growing season. The parcel sent to England in 1915 was only 810 maunds, which after several delays, due to congestion at the port of London after the outbreak of the war, eventually reached the mill. It was made into flour by Mr. A. E. Humphries and distributed to the leading millers in England. The reports received were very favourable and larger samples were asked for. This year, over 5,000 maunds of Pusa 12 were collected by Mr. Burt for export which have been shipped to England by Messrs. Ralli Brothers who, as in previous years, are doing everything possible in bringing the new variety to the notice of the trade in Great Britain. As soon as the milling reports are received, a full account of this part of the work will be published.

In addition to Pusa 12, requests were received from the English millers for samples of Pusa 4 large enough for a full milling test. This request was complied with and about 4,000 maunds of this variety have been shipped by Messrs. Ralli Brothers to London, Liverpool and Hull. Three quarters of this parcel was grown in Bihar on the Dholi, Belsund and Hathowrie estates while the remaining 1,000 maunds came from some of Mr. Burt's wheat centres in Bundelkhand.

Other wheat investigations. In addition to the work relating to seed-distribution and to the establishment of new grades of wheat in India, a large amount of time continues to be devoted to the various wheat investigations in progress at Pusa.

Four series of exceedingly promising new crosses are being worked out in detail. In all these an effort is being made to combine rust-resistance, standing-power, grain quality and yield in the same type. It is expected to evolve from these new forms a set of wheats which will replace all those now under cultivation and also make the most of

India's possibilities as a future producer of wheat. Before they can be distributed to advantage, however, much remains to be done in improving wheat-growing including the control of irrigation water and the proper management of alluvial soils. At present, only a few inches of the surface soil of the great plains are being utilized by the wheat crop and the cultivation of deep-rooting, high-yielding kinds is out of the question. When the need for surface drainage is understood and when the importance of soil-aeration is realized, the wheat crop will be able to make use of a much thicker layer of the alluvium than is now possible. The proper use of green-manure will also increase the rapidity of growth. When these improvements have been adopted, the way will be open for the successful introduction of the new wheats now being made at Pusa.

Tobacco.

Evidence of the popularity of Type 28 for cigarettes and its suitability for widely different soils and climates continue to increase. The Bihar ryots who are growing leaf for the various branches of the Indian Leaf Tobacco Development Company, are demanding the seed of this type in larger and larger quantities, the distribution being carried out by the Dalsing Serai Branch. In Burma, Mr. McKerral reports that Type 28 is doing well for cigarette purposes and that a scheme of seed-distribution is under consideration. In the United Provinces, Mr. Burt has obtained good results with this variety and seed distribution in two Districts is contemplated. Some time ago, very good crops were obtained in the Central Provinces by Mr. Clouston. To meet the increasing demand for seed, nearly half an acre was allowed to flower last season and measures were taken to prevent cross-fertilization. If still larger quantities of protected seed are asked for, the expense involved will be considerable and it may be necessary to ask Government to increase the annual grant for this section.

At the present time in Bihar, the chief direction of progress in tobacco growing is the discovery of some means of lowering the cost of production of this crop. The two chief items in this expenditure are, firstly, the labour involved in the management of the monsoon fallow which precedes tobacco and, secondly, the cost of the manure required. Both these matters have received attention in the Botanical Section. The cost of the monsoon fallow has been reduced by the introduction of the five-tine spring-tooth cultivator by which the efficiency of the plough cattle has been increased threefold and by which it has been possible to keep these fallows clean even in wet years. With regard to the cost of manuring, a method has now been discovered by which heavy, well-ripened crops of leaf can be obtained with green-manure alone. The successful use of *sanai* (*Crotalaria juncea*) as a green-manure for tobacco in Bihar has been found to be a matter of soil-aeration. In the decay of the green crop, a vast amount of oxygen is required and a corresponding volume of carbon dioxide is produced in the soil. For this decay to take place with the necessary rapidity under monsoon conditions, it has been found necessary to promote aeration by suitable surface drainage and by the provision of a certain amount of broken tile (*thikra*) in the surface soil. Under such conditions, the tobacco crop does not suffer from want of air during growth and the ripening processes are not delayed as is the case in green-manuring in the ordinary way. Proceeding in this manner, namely, by green-manuring on drained land containing *thikra*, a crop of cured cigarette tobacco weighing 24 maunds to the acre was produced, which was sold to the Indian Leaf Tobacco Development Company at Dalsing Serai for fifteen rupees a maund. The product was cured on the ground in the country fashion, care being taken to use the minimum amount of moisture in the process. The application of this method under estate conditions is naturally a question of the capital involved in the addition of the necessary amount of *thikra* to the soil. An area of land is now under treatment on the Dholi estate and it is

proposed to publish from time to time the value of the annual produce so that this can be compared with the capital involved in the improvement. There is no doubt of the effect of *thikra* in increasing the value of green-manure. The question that remains for decision is whether the improvement will pay under present conditions. It is expected that the Dholi results will answer this question.

Indigo.

In the last annual report, a detailed account was given of the results of our study of the wilt disease of Java indigo and of the importance of soil-aeration in the development of the roots and root-nodules of this crop. The question of the production, on the Bihar estates, of the seed of Java indigo was also dealt with and the conditions necessary for success were outlined. The general experience of the past indigo season supplied an interesting confirmation of the views put forward in the first and second reports on the improvement of indigo. The monsoon of 1915 in North Bihar was heavy and well-distributed and, in addition to the rainfall, there occurred a series of floods which on most estates cut short indigo manufacture and killed out large areas of the crop. The weather during the first half of August—the period when Java indigo has to be sown for seed—was very wet and few breaks occurred. The almost continuous rainfall after the seed crop was sown, coming as a re-inforcement to the heavy falls in July and the floods, so consolidated the soil and interfered with its aeration that on a comparatively few estates only did the seed crop do well. It was only in cases where the surface drainage was good and the natural aeration of the soil was above the average that Java indigo sown for seed was able to grow normally and produce an average outturn. On the heavier soils in the submontane tract and on the lighter lands which had been flooded previous to sowing, the soil-aeration was so interfered with that the seed crop was attacked by *Psylla* and proved a complete failure. On some of the drained plots at Pusa, the seed crop was distinctly

yellow after the late October flood and a good deal of leaf was lost while the sub-soil was drying during November and December. During the cold weather, the aeration improved and the foliage then became normal both as regards colour and extent.

In the case of Java indigo sown for leaf in early October on the higher lands, quite different results were obtained. After sowing time, little or no rain fell till March and so there was nothing to interfere with the natural aeration of the soil. In many cases, this leaf crop gave small crops of excellent seed, a phenomenon which does not often occur in years when the normal amount of cold weather rainfall is received.

This experience agrees in all respects with the results of the various experiments in growing Java indigo for seed at Pusa. Seed formation, other things being equal, is a matter of soil-aeration. If ample air for the roots of Java indigo is provided, a full crop of seed is obtained. Just as surely heavy and long-continued rain after sowing destroys all hope of a normal yield of seed even when the crop recovers slowly during November and December. In all such cases, the season is missed and flowering begins too late after the cold season has set in and the bees have finished their labours.

As seasons like that of 1915 are to be expected every now and then in Bihar, experiments have been started to determine whether it will pay to treat some of the higher lands on the indigo estates with *thikra* so as to increase the aeration in wet years. These are in progress both at Pusa and at Dholi and the results will be published in due course. At the same time, experiments are in progress to see how far suitable methods of cultivation of the young seed crop will remedy the effects of heavy rain after sowing.

Gram.

An account of the preliminary work on gram was published during the year in the *Memoirs of the Department*

of Agriculture in India. A number of types have been isolated which are being tested for yield under various conditions. A few of these have been distributed for preliminary trials outside Pusa.

As pointed out in the last annual report, the yield of gram like that of indigo depends on the aeration of the roots and nodules. If, however, this crop is grown on well ventilated soils which are also rich in combined nitrogen, the yield of seed always falls off although the amount of growth is enormous. When the crop obtains a large amount of nitrate in solution from the soil and also forms nodules, it is overstimulated and readily becomes too rank. The heaviest and best-ripened gram is always grown at Pusa on well-aerated plots which are distinctly poor in available nitrogen. In the past season, the best crop of gram was obtained by late sowing on a *thikra* plot immediately after the removal of a heavy crop of *patwa* (*Hibiscus cannabinus*). Java indigo grown for seed sometimes behaves in a very similar manner and experiments on this point are now in progress.

Oil-seeds.

The work so far done on safflower (*Carthamus tinctorius*, L.) and *rai* (*Brassica juncea*, H. F. and T.) has just been published in the Botanical Memoirs.

The study of Indian linseed has been begun and an attempt is being made to produce a large seeded linseed for the plains. At present, the types grown on the alluvium have very small seed, the large seeded forms being produced on the soils of Central India. These two classes of varieties are otherwise quite different—those from Central India with large seeds having a deep root system to suit the black soils while those of the plains are surface rooted. Crosses are being made between these types with the object of producing for the alluvium new surface-rooted kinds with large bold seeds. In addition to the inheritance of size of seeds, this study ought to provide interesting results on the genetics of root-development.

Soil-aeration.

The preliminary results obtained on the aeration of soils in India were published during 1915 as Bulletin 52 of the Pusa Institute. A considerable amount of interest has been aroused by this publication of which a second edition was called for during the year. This paper was reviewed very favourably in *Nature* of February 24th, 1916, and has been well received in Europe. A paper on soil-aeration was read at the Indian Science Congress at Lucknow in January last when Mr. Hole, the Imperial Forest Botanist, also gave an account of his work on aeration from the point of view of Indian Forestry. Both these papers attracted a good deal of attention and were keenly discussed.

The views put forward on this subject in Bulletin 52 were amplified and developed in a lecture given to the Board of Agriculture at Pusa last February. This lecture has been passed for printing and will shortly appear as Bulletin 61 of the Pusa Institute. In this paper, the connection between soil-aeration and the development of quality has been outlined and considerable space has been devoted to the practical applications of soil-ventilation including the saving of irrigation water and the increase in crop-production in the plains of India.

Surface drainage.

As in the case of soil-aeration, the publication of Pusa Bulletin 53 on soil-erosion and surface drainage has led to such a large demand for copies that a second edition of this paper had to be arranged within a year of the appearance of the first. This bulletin was written largely as an introduction to the discussion on these subjects which took place at the last meeting of the Board of Agriculture. The views put forward in this paper were accepted by the Board and three resolutions, largely based thereon, were recommended to the consideration of the Government of India.

Interest continues to be taken in the Pusa system of surface drainage which is to be seen at Dholi on an estate

scale. A large number of visitors saw this estate during the year and this method of drainage is now being taken up in Bihar. His Highness the Maharajah of Darbhanga is showing a personal interest in this matter and a beginning has been made on several of his estates. In this work Mr. R. S. King, Sub-Manager of the Jhanjharpur Circle of the Raj, is taking the keenest interest both in local drainage schemes on the Darbhanga properties and also in the scheme for the preparation of a contour survey of North Bihar. In the United Provinces, the Pusa method of drainage has been adopted at two centres and results similar to those in Bihar have been obtained.

Perhaps the most notable advance in drainage in Bihar during the year is the fact that the Commissioner and the District Embankment Committees of the Tirhoot Division are taking up the question of the general drainage of Bihar on the basis of a drainage map, constructed on the lines of the system introduced by the late Sir Edward Buck. A joint meeting of the District Embankment Committees of the Division was held at Muzaffarpur in December 1915 when the general lines of future work on this subject were discussed.

III. The Development of the Agriculture of Baluchistan.

Although started for local objects, the foundation of the Fruit Experiment Station at Quetta has led to the discovery of results of considerable importance to Indian Agriculture. These apply particularly to the irrigated tracts of India and are concerned with the saving of water in wheat-growing and with improved methods of growing fodder crops.

Water-saving.

The earlier results on water-saving in wheat-growing were published during the year in Bulletin No. 4 of the Quetta series. In this paper, the opportunity was taken of stating very briefly the main principles on which the right use of irrigation water depends. A careful com-

parison of these principles with the practices in vogue in the irrigated areas of Baluchistan cannot fail to show that an enormous quantity of valuable water is now being wasted. As the principles underlying water-saving are not understood and little has been done in utilizing the present supplies to the best advantage, it will not be out of place briefly to refer to them here. Both experience and experiment prove that if the maximum duty of irrigation water in wheat-growing is to be obtained, special attention must be paid to the following five principles:—

1. The irrigation water available must be spread over the largest possible area.

2. Heavy waterings reduce the proportion of grain to total crop.

3. The growth period of wheat is increased by heavy waterings.

4. When the water supply is limited, the root development of the wheat crop must be deep.

5. The soil moisture must be preserved, as far as possible, by a surface mulch of dry soil.

Applying these principles to the conditions of the Quetta valley, it was found that the highest duty of water could be obtained by irrigating the land once a few days before sowing and by breaking up, by means of the lever harrow, the rain crusts formed during winter and spring. The average yield on large scale trials on unmanured land at the Experiment Station worked out at $17\frac{3}{4}$ maunds of grain per acre. The zamindars, on the other hand, often water their wheat six times after sowing and obtain an average of $13\frac{1}{2}$ maunds of grain. The same amount of water spread over seven acres, if used according to the method employed at the Experiment Station, would give 7 times $17\frac{3}{4}$ or $124\frac{1}{4}$ maunds of wheat. The difference in favour of the experiments is therefore $110\frac{3}{4}$ maunds of wheat. If the average irrigated acreage of wheat in the Quetta valley is multiplied by 100, the result would indicate, in maunds of wheat per annum, the present annual waste of water on this crop alone. On every 200 acres of

irrigated wheat, the water now lost would produce 20,000 maunds of grain and a large amount of straw of a total value not far short of a lakh of rupees.

During the past wheat season, the new methods have been tried on zamindars' land near Quetta. One watering was given at the end of September before sowing and in spite of the fact that the winter rains did not set in till late in January, two months later than usual, a very good crop resulted, the grain of which was well above the average in quality. The yield of grain was 22 maunds 32 seers per acre, while the *bhusa* amounted to 43 maunds 20 seers. This result, in spite of the lateness of the winter rains, is five maunds higher than the average obtained at the Experiment Station. This is due to the fact that the wheat land at the Experiment Station is high-lying, exposed to the sun and wind and its water-holding capacity is less than that of the typical wheat lands of the valley. The Experiment Station yields have therefore been exceeded by the zamindars in a season of badly distributed rainfall when the local dry-crop wheat was a failure.

These results have naturally attracted a considerable amount of attention. On May 29th, a meeting of the *maliks* of the valley was arranged at the demonstration area when the Agent to the Governor-General and the chief officials of the Baluchistan Administration were present. On June 5th, the Political Agent brought the *maliks* of the Pishin valley to see the results. These visits were entirely successful, a keen interest was shown by those present and large areas of land were at once offered for demonstration work for the next season's wheat crop. Sir John Ramsay has ordered 25 pairs of lever harrows, some of which will be given as *khillats* at the September *Darbar*. The irrigation policy of the Administration has recently been revised, partly as a result of these experiments and particular attention will, in future, be paid to water-saving and to the increase in the duty of the present supplies.

The investigations on water-saving are being continued and during the year further results were obtained, an

account of which is now being prepared for publication. These refer to the improvement of water channels, to the most suitable form of *kiari*, to the proper slope for flood irrigation and to the control of the water while being applied to the land.

The improvement of fodder production.

In addition to the saving of irrigation water, there is another direction in which the productive power of the land in Baluchistan can be increased. This is in the provision of a fresh source of organic matter for supplementing the present supplies of farm-yard manure. The addition of organic matter to the soils of the Quetta valley does much to increase their porosity and water-holding capacity and also to mitigate the evil effects of surface-flooding. The growth of Persian clover (*Trifolium resupinatum*), locally known as *shaftal*, has been found to improve the cropping power of the land very considerably and to be a valuable source of organic matter, particularly if the last crop is ploughed in as a green-manure. It also supplies a large quantity of valuable fodder and is a simple means of utilizing the winter rains.

Some attention has been paid to increasing the yield of *shaftal* and other crops at Quetta, and to the best means of improving the duty of water in fodder growing. Such crops grow faster and need less water, if the land is manured in the first instance with farm-yard manure at the rate of 15 to 20 tons per acre. The proper grading of the surface and the use of long *kiaris* (about $300' \times 25'$) watered from one end of the field leads to an even flow of the irrigation water over the land and to uniform percolation. In this way, a great saving of water takes place. The expense and trouble of the preliminary grading and levelling and of the adoption of the most suitable form of *kiari* are well repaid by the amount of water saved, by the ease with which irrigation can be carried out and by the evenness of the resulting crop.

During the past season, one of the plots at Quetta, which was not in very good condition, was put down in

shaftal in August 1915. The land was manured with farm-yard manure at the rate of about 20 tons per acre and sown with *shaftal* under a thin cover-crop of maize. Six cuts of clover were obtained by the middle of June 1916, the total weight of which was over 33 tons per acre. At eight annas per 100 lb., the year's produce is worth Rs. 371 per acre—an income obtained with the minimum expenditure of water and resulting in an increased fertility of the land. This result, which has been confirmed many times at Quetta, indicates the methods which should be adopted in fodder growing in India—intensive cultivation with the minimum expenditure of irrigation water.

While *shaftal* has proved a useful green fodder, particularly for dairy cows and buffaloes, its best use to Baluchistan is in the form of clover hay, put up in bales suitable for storage and for easy transport on mules or camels. Real hay is unknown in India, its place being taken by in-nutritious substances like dried grass and *bhusa*. A considerable amount of attention has therefore been paid to the drying and baling of *shaftal* and to the preparation of real hay. In European countries, the difficulties in hay-making are concerned largely with the slow rate of drying and with the interference caused by frequent showers. At Quetta, the problem is reversed. The air is so dry and the sun is so strong that the hay easily becomes overdried and so brittle that it is broken to powder when handled. Baling such a product is out of the question and even if it could be stacked, no mild after-fermentation could take place. These difficulties are overcome by drying in stages in heaps on the field and by preserving sufficient natural moisture for a slight fermentation to take place in the stack before baling. Early last year, trials of the new baled fodder were carried out with the horses of the 72nd Heavy Battery at Quetta under the Commandant, Colonel H. M. Courtenay, R.A., who reported very favourably on the results. The transfer of this unit and the death of the Commandant on active service put an end to the trials. They have, however, been continued by Brigadier-General

Cook, R.G.A., with one of the mule teams of the 4th Mountain Battery. The trial has been a great success and the mules did better on *shaftal* hay than on their ordinary ration of *bhusa* and grain. The saving in weight was about 30 per cent. and the cost was also substantially reduced. There is now little doubt that the use of baled *shaftal* as fodder for Army purposes would mean a reduction in the weight of forage of some 30 per cent., a point of considerable importance on the Frontier where the difficulties of transport are so great.

Shaftal and lucerne are by no means the only leguminous plants in North-West India, that could be made into hay and pressed into bales. There should be no difficulty in drying and pressing crops like *berseem* and *senji* which are already cultivated in Sind and the Punjab respectively. The albuminoid ratio of such fodders is much above that of *bhusa* and there is a great opening for such produce both in the Army and also in the cities and on the main roads of North-Western India. Later it might spread to the cultivators and for the building up of fodder reserves for use in time of famine. Once such fodders as *shaftal* hay find their way into Indian agriculture, the efficiency of the ox, on which the system rests, will increase and at the same time the producing power of the land will improve.

Besides their local significance, these results on water-saving and fodder-growing have a distinct bearing on the development of Indian Agriculture. To anyone who can read his practice in the plant, there can be no doubt that in the irrigated tracts of the country, a great waste of valuable irrigation water is going on which is not only lost but also damages the standing crops and tends to lower the general fertility of the country. There are many tracts in India where a perennial system of irrigation is scarcely suitable and where the duty of water might be increased by working on older lines and by substituting in its place a modified form of inundation. The problem of using the present supplies of water in India in wheat-growing is largely physiological and depends for its solution on a knowledge

of the functions of the plant. Crops like wheat require a well aerated soil as well as a sufficient supply of moisture. The continual surface flooding which takes place in a perennial system of irrigation destroys the natural texture of the soil and interferes with its aeration. The addition of more water to a crop in which the yield is already limited by want of air cannot possibly produce any useful result. Particularly is this the case on the fine alluvial soils of the plains and on the black soils of the Peninsula. The problem of obtaining the maximum duty of water is to supply moisture without depriving the soil of air. In many cases, this can be accomplished by a single irrigation before sowing followed by moisture conservation methods like those adopted at Quetta. In other cases, the amount of water can be reduced by increasing the water-holding capacity of the soil by green-manure and by other methods now being worked out. Any saving of irrigation water in India is an advantage both to the people and to Government. The less water used the less is the damage done to the country and the larger is the area irrigated. Government benefits by a growing revenue and by increased opportunities for the settlement of discharged sepoys and of the surplus population of congested districts. Under the present system of perennial irrigation, India is rapidly reaching the limit of profitable expansion with the water now available. Any great extension must be achieved by increasing the duty of water, a problem full of possibilities for the country but one on which hardly any attention has yet been bestowed.

Fruit investigations.

It is proposed to defer till the next annual report any detailed account of the results which are now rapidly accumulating with regard to the cultivation and propagation of fruit trees and to the transport of the fruit itself. Many of the problems relating to these matters are on the point of solution and in another year the subject can, in all probability, be dealt with much more definitely and satisfactorily than at this moment.

Improved fruit boxes. As far as the design of suitable fruit boxes for the Quetta trade is concerned, this portion of the work may be said to be completed. The only thing that remains is the discovery of the cheapest and most satisfactory source of the box boards and cardboard. A large amount of time has been spent in trying to discover whether the box boards could not be obtained in India itself. After numerous enquiries, an Indian firm was discovered whose tenders were satisfactory. The execution of the orders, however, left much to be desired and when enquiries were made as to future supplies of a more satisfactory character an attempt was made to increase the price far beyond the value of the material. For the present, it has been found more satisfactory to import the boards from Great Britain in spite of the increase in cost due to the war and to the rise in freights.

The demand for the improved boxes showed a most satisfactory increase during the summer of 1915, and about 3,176 boxes and 2,200 two pound punnets were sold. For many of these packages the demand was greater than the supply and the entire stock was sold long before the end of the season. For 1916, a much larger supply has been procured, more than sufficient for any possible demand that is likely to arise.

The new cardboard boxes have proved a great success and are in active demand. These can be used as returnables and last for three or four journeys to and from Quetta. In this way, the expense is reduced and the cost of the package each journey for five seers of choice peaches comes to less than four annas. Another advantage of these cardboard boxes is that they are thief-proof and cannot be tampered with in transit without immediate detection.

One indirect result of the new boxes should be mentioned, namely, the stimulus they have given to new planting. A great demand for nursery stock has arisen and many large fruit gardens are being put down. To meet this, the number of trees issued by the Fruit Experiment

Station is being rapidly increased and by the end of 1917, it is expected that all possible requirements can be met.

IV. Programme and publications.

Programme of work for 1916-17.

Work will be continued on the following crops on the lines indicated in the annual reports and in the publications of the section—wheat, tobacco, gram, fibre plants, indigo, oil-seeds, fodder crops and fruit.

Publications.

The following papers were published during the year. In order to bring the list up to date and to make it correspond with this report, all papers in the press which are due to appear before the end of July 1916, have been included. The Urdu editions of three of the Quetta Bulletins were prepared by members of the staff of this section :—

1. Soil aeration in Agriculture. *Bulletin 61, Agricultural Research Institute, Pusa,* 1916.
2. Soil ventilation. *Bulletin 52, Agricultural Research Institute, Pusa,* Second Edition, 1916.
3. Soil Erosion and Surface drainage. *Bulletin 53, Agricultural Research Institute, Pusa,* Second Edition, 1916.
4. Report on Agricultural Botany for 1914-15, for the Board of Scientific Advice.
5. The importance of soil ventilation on the alluvium. A paper read at the Indian Science Congress, Lucknow, 1916, and published in the special Congress number of the *Agricultural Journal of India,* 1916.
6. The Application of Botanical Science to Agriculture. A paper read at the Indian Science Congress, Lucknow, 1916, and published in the special Congress number of the *Agricultural Journal of India,* 1916.
7. The manurial value of potsherds. *Agricultural Journal of India,* Vol. XI, Part 3, 1916.
8. Some improvements in the packing and transport of fruit in India. *Bulletin 2, Fruit Experiment Station, Quetta,* Second Edition, revised, 1915.

9. Soil ventilation. *Bulletin 3, Fruit Experiment Station, Quetta,* 1915.
10. The saving of irrigation water in wheat-growing. *Bulletin 4, Fruit Experiment Station, Quetta,* 1915. Reprinted in the *Agricultural Journal of India,* Vol. XI, Part 1, 1916.
11. Clover and Clover Hay. *Bulletin 5, Fruit Experiment Station, Quetta,* 1915. Reprinted in the *Agricultural Journal of India,* Vol. XI, Part 1, 1916.
12. An improved fibre plant. *Agricultural Journal of India,* Vol. X, Part 3, 1915.
13. Some varieties of Indian gram, *Cicer arietinum,* L. (with Abdur Rahman Khan). *Memoirs of the Department of Agriculture in India (Botanical Series),* Vol. VII, No. 6, 1915.
14. Studies in Indian oil seeds. No. 1. Safflower and Mustard (with Abdur Rahman Khan). *Memoirs of the Department of Agriculture in India (Botanical Series),* Vol. VII, No. 7, 1915.
15. On the inheritance of some characters in wheat—II. *Memoirs of the Department of Agriculture in India (Botanical Series),* Vol. VII, No. 8, 1915.
16. The wheats of Baluchistan, Khorasan and the Kurrum Valley. *Memoirs of the Department of Agriculture in India (Botanical Series),* Vol. VIII, No. 1, 1916.
17. The storage of seed. *Agricultural Journal of India,* Vol. X, Part 3, 1915.
18. A new seed-drill. *Agricultural Journal of India,* Vol. X, Part 3, 1915.
19. Mixed crops. *Agricultural Journal of India,* Vol. XI, Part 3, 1916.
20. Zamin men hawa ki ámad va raft. *Risála 3, Quetta,* 1916.
21. Gehun ki ábpáshi men kifait shuari. *Risála 4, Quetta,* 1916.
22. Shaftal aur uska khamir shuda khushk chárá. *Risála 5, Quetta,* 1916.

REPORT OF THE IMPERIAL MYCOLOGIST.

(E. J. BUTLER, M.B., F.L.S.)

I. CHARGE AND ESTABLISHMENT.

Mr. F. J. F. Shaw, B.Sc., A.R.C.S., officiated as Imperial Mycologist until November 16th, 1915, when I resumed charge of the section on return from combined leave. The post of Second Imperial Mycologist was created during the year and filled by Mr. Shaw, Supernumerary Mycologist, on October 19th, 1915. Muhammad A. Hafiz Khan, 3rd Assistant, was transferred on deputation to the Forest Research Institute, Dehra Dun, with effect from September 22nd, 1915. The vacancy thus created was filled by promotion from the staff, Babu N. C. Sen coming in as second clerk. Five of the staff volunteered for service in Mesopotamia in connection with the campaign against flies, just before the close of the year, and two of these have since been accepted. All have worked well.

II. TRAINING AND VISITORS.

Babu J. B. Sinha, Fieldman in Mycology, Sabour, completed his course of training at Pusa on September 29th, 1915. Babu K. P. Roy, a scholar from the Bengal Department of Agriculture, joined on August 10th, 1915, and finished his course on May 31st, 1916. Mr. Deoki Nandan, B.A., M.R.A.C. and Mr. B. N. Vakil took special courses as private students from May 23rd and between March 15th and April 25th, respectively. Prof. K. C. Mehta, M.Sc., Professor of Botany, Agra College, worked in the section from March 3rd to 26th and Mr. G. S. Kulkarni, Mycological Assistant, Bombay, Department of Agriculture, from March 23rd to May 24th. Mr. A. C. Tunstall, Mycologist to the Indian Tea Association, visited the section from January 15th to 25th, 1916.

III. Diseases of Plants.

The investigation of the diseases of plants, the collection and identification of Indian parasitic fungi, and advice and assistance to officers of the Department and the general public, formed as usual the chief work of the section.

(1) Paddy diseases. The most important disease at present under investigation in the section is that known as "ufra" of rice, which continues to extend and attract increasing notice in Eastern Bengal. It is now throughout most of the districts of Noakhali, Tippera and Dacca and is extending into Mymensingh and probably Sylhet. With a view to testing measures for checking its ravages by experiments within the affected area, I selected a site near Comilla in 1912, and arranged for its acquisition as a temporary measure and also for complete control of its water supply by bunding, to prevent risk of infection from neighbouring fields. Subsequently it was decided by the local Department not to acquire the land, arrangements being made with the cultivators in the selected area to carry out our instructions. This did not prove satisfactory; the instructions were not followed, the bunds were defective and were cut through when water became scanty and the crop was harvested before it could be inspected. Owing to the evident difficulty of securing effective control of the selected site, it was abandoned last year and arrangements have been made to carry on the work in the neighbourhood of Dacca. Meanwhile small plots were instituted at Pusa in 1912, in order to duplicate the work under more rigorous control. It has been necessary to confine the Pusa work within narrow limits to avoid risk of the disease escaping from the plots to the surrounding cultivation; and only one or two experiments have been possible each season, outside those which could be carried on in the laboratory. The information obtained has, however, been considerable. It has been proved that a diseased plot will inevitably give a diseased crop the following year, if the stubble is allowed to rot on the ground as is the usual practice in the infected

area, but that if all the stubble is removed, a healthy crop can be grown. Furthermore it has been shown that the parasite can extend along the water courses, both with and against the stream, and infect neighbouring plots, but the distance travelled has hitherto been small. When atmospheric humidity within the crop is low, extension is hindered, but provided the humidity conditions are right, new cases of disease may become evident even on large plants within a month and many plants may be destroyed within two months of liberating the parasite in the water supply. Though under normal conditions the parasite passes into a dormant condition in the rotting stubble in the interval between successive crops (say from December to April), it can be kept in an actively parasitic state through this period by supplying it with constantly renewed young growing paddy for food, and this fact may increase our difficulties in dealing with it where the crop known as *boro* paddy is grown, fortunately a relatively small area. On present information it seems probable that the *boro* crop harbours the parasite, but that the low atmospheric humidity during the winter and spring months, when this crop is growing, checks extension and perhaps also interferes with the multiplication of the parasite. It is this same factor that doubtless explains the relatively little damage caused to the early (*aus*) crop and to the main crop in its early stages; experiments at Pusa have shown that so long as the above-ground parts of the plant are maintained dry, it is difficult to get successful infections, even though the roots and base of the plant are in mud and water, whereas during the monsoon or when inoculated plants are covered by bell jars, infection readily occurs. When insufficiently provided with moisture the parasite tends to pass into a dormant condition and ceases feeding.

Laboratory work was directed to attempts to establish conclusively that the cause of the disease is *Tylenchus angustus*, the eelworm described in Bulletin No. 34 of 1913. Attempts to obtain it in pure culture failed but conclusive proof was ultimately got by a series of experiments which

established that minute portions of infected plants were only infectious when they contained on them individuals of this species. During these experiments it was found that definite symptoms may be induced in healthy seedlings within a week when a moderate number of worms is used for inoculation. A minute strip of plant carrying, say, 20 worms can be relied on to produce the disease in covered seedlings, while a similar strip from the same plant and part but without worms, is harmless. About a hundred successful inoculations have now been carried out under conditions which leave no room for doubt that the actual parasite is this worm—perhaps the first case in which an ectoparasitic eelworm has been found causing serious injury to plants. Other points determined are that the worm is not strictly aquatic, as it perishes in some weeks if wholly immersed in water. Kept dry it lives longer, as it has the faculty of coiling itself up into a twisted mass, which resists moderate desiccation for at least some months. It appears to be unable to grow much or moult unless supplied with its usual living food and hitherto has not been found to grow or feed on anything else than living paddy plants. On paddy it is limited to parts where the outer walls of the epidermal cells are unthickened, and in young plants penetrates the bud to reach the young leaves near the growing point as soon as possible. This position is reached not by burrowing through the tissues but entirely by passing between the folds of the bud. Several experiments were carried out to test the ability of the worm to remain alive in soil, and the results indicate that it cannot survive during the interval between successive crops in this manner.

All the work hitherto carried out confirms the conclusion previously arrived at, that the parasite is normally perpetuated by means of the stubble, which it is the practice in the infected area to leave on the fields after harvest. The problem of dealing with the disease therefore resolves itself into ascertaining the best way of removing or destroying this stubble. This can be done thoroughly by

raking it into heaps and burning it. It can perhaps be equally effectively carried out by early ploughing so as to bury the debris of the previous crop. Both these methods, however, are likely to interfere, if carried out on a large scale, with the local fodder supply and it seems necessary to ascertain whether diseased straw can safely be fed to cattle. There will be no need to defer active operations while such relatively minor points are being investigated, and it is hoped that the destruction of the stubble will be attempted on a large scale in the near future.

(2) " Tokra " of tobacco and mustard. The work of past two seasons has established that the parasitic species of *Orobanche* in Bihar are *O. indica* Ham. and *O. cernua* Loeffl. The species *O. cernua* is the common parasite of solanaceous crops in Bihar but does not appear to attack *Cruciferæ* save in very exceptional circumstances. In a crop of mustard, grown in a field known to be badly infected with both species of Orobanche, only four cases of *O. cernua* were found among many thousands of *O. indica*. The parasitism of *O. cernua* therefore is more restricted than is that of *O. indica* which, while being a serious parasite of *Cruciferæ*, does occur to a not inconsiderable extent on *Solanaceæ*. The life histories of the two species seem to be identical, the " tokras " appearing a few weeks after the host crop is well established and rising to flower and fruit along with it. Both species rely on the production of countless millions of minute seeds for their dissemination and perennation. These seeds are present all over the cultivated lands of Bihar, their number and minute size being extremely favourable to their dispersal in the strong winds of February and March when the fruits of *Orobanche* are ripe.

Experiments were carried out during the year with a view to discovering whether the addition of quantities of sodium nitrate to crops of mustard and tobacco had any influence on the number of " tokras " which occurred in the crops. Plots of equal size were selected in land which was known to be infected with both species of *Orobanche* and

the numbers of " tokras " occurring in plots to which sodium nitrate had been added were compared with the numbers of " tokras " in plots which had not received any nitrate. A difficulty which renders the results of the first season's work on these lines somewhat inconclusive is that the number of " tokras " appearing in a plot will depend, apart from any influence of artificial manures, on the amount of " tokra " seed which the plot contained. This factor appeared in many cases to mask any effect which might have been due to the addition of sodium nitrate. The work will be continued for another year in order to eliminate this source of error but the results obtained to date do not lend any support to the view that sodium nitrate will be found a specific remedy for " tokras."

(3) Black thread of rubber. Work on the " black thread " disease of Hevea in Burma was continued. A popular account was published as a bulletin of the Burma Department of Agriculture and a more technical memoir is in the press. The disease first breaks out soon after the rains begin and completely disappears after the close of the monsoon. It is not fatal to the tree but does much damage by attacking the tapped area of the bark. Infected areas do not yield latex and severely diseased trees have to be excluded from the tapping round. In 1914 the loss of rubber on one estate was 2—3,000 lb. and in 1915, 8—9,000 lb., there being 12,000 trees affected in 1914 and 42,000 in 1915, out of 77,000 in tapping. The cut surface of the tapped bark becomes marked by vertical cracks, from which latex occasionally exudes; sometimes a thick cushion of coagulated latex forms below the renewing bark, causing the latter to bulge out and ultimately fall off so as to leave an open wound. The renewal of the bark is irregular, masses of callus appear on the cut surface and further tapping is hindered.

The cause of this damage is a species of *Phytophthora*, differing from the well-known canker fungus, *Phytophthora Faberi*, to which it had been attributed in the Dutch Indies. It seems to occur in Ceylon also but has been there

supposed to result from climatic conditions. In South India the same fungus is believed to be responsible for considerable damage and it is at present under study by the Madras Department.

The fungus is found both in the diseased bark and also on the fruits. It has been grown in pure culture and an extensive series of inoculations carried out both on rubber and on numerous other plants known to be attacked by species of *Phytophthora*. On rubber it is a wound parasite, being unable to infect the undamaged bark; through wounds it infects readily and produces the characteristic symptoms of the disease. Of the other plants tried, the ordinary hosts of *Phytophthora infestans*, *Ph. parasitica* and *Ph. Colocasiæ*, the three species most commonly found in Northern India, are immune, as also is cacao, one of the chief hosts of *Ph. Faberi*, and many other plants known to be liable to *Phytophthora* attack. Only on seedlings of the garden plants, *Gilia* and *Salpiglossus*, were successful infections secured.

The disease is favoured by excessive humidity and shade and is, therefore, worst in thickly planted rubber estates. The free admission of sunlight and air checks its progress, and good results may be obtained from judicious pruning and thinning. The chief source of infection seems to be the fruits, and as these have practically no value, and develop in the rains a copious growth of the parasite, from which spores are shed on the bark, it is recommended that all fruits be carefully picked and destroyed before the monsoon breaks, in infected plantations.

In continuation of the studies on allied species of this genus which have been carried on at Pusa in recent years, an account of a form of *Phytophthora parasitica* found on *Vinca rosea* has been recently submitted for publication. Germination of the durable type of spore (the oospore) has been obtained and was found to correspond in essentials with that described for *Ph. erythroseptica* in Ireland.

(4) Opium poppy blight. The investigation of this disease has led to the conclusion that while *Peronospora*

arborescens is a normal parasite present in almost every poppy field and probably, like most of its tribe, only epidemic under favourable climatic conditions for its spread, *Rhizoctonia* develops chiefly in fields in which the drainage is defective. The Economic Botanist, United Provinces, has discovered certain varieties which appear to be almost immune to *Peronospora* and in the growth of these and improved cultivation and drainage lies the best hope of preventing loss of the crop.

(5) *Rhizoctonia* on jute and sugarcane. Samples of jute seed from Dacca were found to contain the sclerotia of *Rhizoctonia Solani* Kühn adhering to the seed. The parasitism of this fungus upon jute has been the subject of a previous publication but up to the present *R. Solani* has been a source of damage in the region of the " collar " and has not been known to infect seed. It is not clear how this comes about and the matter will receive further investigation.

Specimens of sugarcane received from the Central Provinces were found to be infected with a sclerotial fungus. The fungus was obtained in pure culture and strongly resembled *Rhizoctonia destruens* Tass.; moreover inoculations upon *Delphinium* (the original host of *R. destruens*) and upon betle vine were successful. Further infections upon sugarcane resulted in the death of the outer leaves and of the young shoots at the base of the plant; the infections are still progressing at the moment of writing. In the field the fungus causes a bright red spot on the leaf sheath and this is the first noticeable result in artificial infections. In badly diseased specimens the leaf bases are dark red and have a fibrous appearance as if the parenchyma had been rotted away leaving the vascular bundles. On stripping the leaf bases the stem has a pale pink colour under the epidermis and in section the interior shows a generally diffused salmon pink colour partly obscured by a thick white felt of hyphæ. The mycelium shows a tendency to form strands of hyphæ in a manner suggestive of *R. destruens*. Further research is in progress.

(6) Anthracnose of peppers. The disease of betle pepper referred to in previous reports as being probably due to an anthracnose fungus, has proved more difficult to elucidate than was anticipated. All attempts to produce it artificially by inoculating with cultures of the suspected fungi have failed. In the absence of definite knowledge of the cause no useful recommendations for treatment can be offered.

The chilli anthracnose (due to *Colletotrichum nigrum*) is a serious disease of this crop in several parts of India. It was prevalent in Bihar last year and some spraying experiments were tried. Later on it appeared that a more hopeful line of treatment lay in the use of disease-free seed and investigations are in progress to test this method. It has been found that, as in the allied bean anthracnose, the parasite penetrates the pod and reaches the seed. If such seed be sown the following season a certain number germinate and give seedlings on which the fungus may be found. Such seedlings must serve as a source of infection to their neighbours and it seems probable that this is one of the main ways by which the disease is perpetuated. If seed only from healthy pods be used this source of infection can be eliminated, and further experiments are in progress to test the effect of this on the subsequent crop.

(7) Plantain diseases. An account of a plantain disease prevalent at Pusa was published early in the year. It is a wilt, caused by a species of *Fusarium* allied to, but distinct from, that which causes the dreaded Panama disease of the New World. The parasite was grown in pure culture and successful inoculations with it secured. In mild attacks the growth of the plant is not checked but in more severe cases the rot reaches the stem and may kill the whole crown. Much loss is also caused when the stalk of the fruit bunch becomes attacked as this may lead to total destruction of the bunch. No method of treatment has been found.

A second plantain disease, familiar in India, is the fruit rot caused by *Gloeosporium musarum*. Attempts to

check this by spraying have been in progress for a considerable time. It has been found that early spraying with Burgundy mixture, beginning in June and repeated every fortnight until the fruit is nearly ripe, when ammoniacal copper carbonate should be used, is successful in preserving the fruit from the disease. An account of the method has been published.

(8) Sal tree disease. The disease of sál trees, mentioned for the first time in the last annual report of the section, has appeared again this year in the forest of Buxa Duars and is also reported in the Gorakhpur division. The symptoms of the disease and the fungus which occurs on diseased trees are exactly the same as in the previous description. Specimens of the fungus sent to Kew have been identified as *Polyporus Shoreæ* Wakefield—a species new to science—and the description published in the Kew Bulletin. The fungus is said to be readily distinguished from other species by the hard but brittle texture of the pileus, especially of the pores, when dry and the wrinkled deeply cracked dark crust. In living specimens the soft swollen whitish margin of the pileus is a distinctive feature. The basidia are normal and each bears fine hyaline spores from 2·5—3·5μ in diameter.

In culture the fungus grows well on a variety of media. On glucose agar the mycelium is largely submerged and produces a dense brown pigment; the hyphæ very often segment into spores. On sterile corn meal the fungus nearly always produces structures which suggest fructifications; so far however they have not produced any basidia or spores. The excretion of a yellowish liquid is a feature common to these structures in culture and to the pileus in the field.

Inoculations were carried out in the jungle at Rajahbhatkhawa in September of last year but defects in the method of this preliminary experiment, combined with the lateness of the season at the time of making the infection, proved unfavourable, and no conclusive results have so far been obtained. The inoculations were repeated this June,

with modifications suggested by the previous experiment, and a further series of infections is about to be carried out at Dehra Dun in co-operation with the Forest Botanist; it is hoped that these will yield decisive results.

(9) Other diseases of interest. The " black-dot " disease of potatoes caused by *Vermicularia varians*, was reported from Ranchi during the year. It was previously known only in France, Australia and South Africa. The extent of the injury it can cause is not yet determined. Peach leaf curl was found in the same locality and is reported to be very prevalent around Peshawar. It is hoped to arrange for trials in its treatment during the coming year. A disease of shaftal (*Trifolium repens*), caused by *Polythrincium Trifolii* (new to India) was found near Peshawar. Diseases of barley were much in evidence in the Pusa crop last season, the chief parasites recorded being *Puccinia simplex* and *Ustilago nuda* (not previously seen in India), *Puccinia glumarum*, *Ustilago Hordei* and *Helminthosporium gramineum*. A case of serious injury to a mango orchard at Malda from the fumes of a brick-kiln was examined. It differed from previous cases of the kind in the injury being chiefly to the fruit, not the branches. It is evident that the mango is peculiarly susceptible to such fumes. The study of the smuts of jowar, which are amongst the most destructive diseases in India, has been taken up by Mr. Kulkarni, Mycological Assistant to the Bombay Department of Agriculture, who completed his investigation at Pusa. No less than four distinct species attack this crop but the two more usual forms can readily be prevented by seed treatment. It is hoped to secure the universal adoption of this treatment ultimately, with a saving to the cultivators of several crores of rupees annually.

IV. Miscellaneous.

During my absence on leave the manuscript of a book on fungi as a cause of plant disease in India was almost completed. It has since been finished and revised and the

preparation of illustrations is now in hand. While engaged at Kew on this work an opportunity was taken of checking the nomenclature and determining the identity of many of the fungi that are responsible for crop diseases in India, by comparison with type material from the Herbarium of the Royal Botanic Gardens. I have to acknowledge the generous facilities given me by the Authorities at Kew and invaluable assistance from the Herbarium staff, especially Miss Wakefield and Messrs. Massee and Cotton.

As a result of the International Phytopathological Conference held at Rome early in 1914, the possibilities of legislation for the control of the spread of plant diseases have been recently much discussed. With the permission of the Secretary of State, I prepared a note for the Royal Horticultural Society on the dissemination of parasitic fungi as a basis for international legislation. This has since been written up with special reference to Indian problems and submitted for publication as a memoir of the Agricultural Department. At the Rome Conference a draft International Convention was signed by the delegates of some 30 States, and India will probably have to decide whether to adhere to this Convention or not, in the near future. Much consideration has been given to this question during the past year so that we may be in a position to advise when called on to do so.

V. Systematic Work.

The fifth part of "Fungi Indiæ Orientalis," based on material sent to Germany before the war, was published during the year. It includes a first instalment of determinations of the Pusa Herbarium collections of *Deuteromycetes*, comprising the *Sphaerioideæ* (173 species), *Nectrioideæ* (7 species), *Excipulaceæ* (4 species), *Leptostromataceæ* (3 species) and *Melanconiaceæ* (8 species). Seven new genera and 97 new species are described, the large proportion (nearly 50 per cent.) of new forms being due, no doubt, to the relatively little attention previously devoted to this group in the East. Many of them are crop parasites but

they are not, on the whole, responsible for as much damage as the mildews, rusts and smuts. The number of mounted sheets added to the herbarium during the year was 258.

VI. Programme of work for 1916-17.

(1) *Research work.* New fungus diseases of crops will be investigated as occasion arises but the following diseases will receive special attention and will constitute main lines of investigation.

(1) Ufra of paddy
(2) "Tokra" of tobacco and mustard
(3) Sclerotial disease and smut of sugarcane
(4) Wilt diseases of cotton, sesamum, gram and chilli
(5) Root rot of sál tree.

As minor investigations it is hoped to continue work on the anthracnoses of some field crops (especially chilli) and fruits.

(2) *Systematic work.* This will probably be in abeyance for the present, owing to difficulties in obtaining assistance from abroad on account of the war.

(3) *Training.* This will be continued on the same lines as in previous years.

(4) *Routine work.* Advice and assistance will be given as usual to Provincial Departments of Agriculture, the Forest Department, Planters' Associations and the general public.

VII. Publications.

(1) Shaw, F. J. F. & S. L. Ajrekar. The genus Rhizoctonia in India. *Mem. Dept. of Agri., India, Bot. Ser.* VII, No. 4, August, 1915.

(2) Shaw, F. J. F. .. Report on Mycology, 1914-15, for the Board of Scientific Advice.

(3) Dastur, J. F. . A Rot of Bananas. *Agr. Jour. of India*, Vol. X, Part 3, July, 1915.

(4) Dastur, J. F. . Spraying for Ripe-rot of the Plantain Fruit. *Agr. Jour. of India*, Vol. XI, Part 2, April, 1916.

(5) Dastur, J. F. Black Thread disease of Hevea in Burma. *Bull. 14, Department of Agriculture, Burma*, 1916.

(6) Sydow, H. & P. & E. J. Butler. Fungi Indiæ Orientalis. *Annales Mycologici*, XIV, Nos. 3 and 4, 1916.

REPORT OF THE IMPERIAL ENTOMOLOGIST.

(T. BAINBRIGGE FLETCHER, F.L.S., F.E.S., F.Z.S.)

I. CHARGE AND ESTABLISHMENT.

The Imperial Entomologist held charge of the Section throughout the year ended 30th June 1916. The post of Supernumerary Entomologist remained vacant throughout the year owing to the impossibility of obtaining any suitable candidate during the war. Mr. Misra, First Assistant, was on privilege leave from 24th May until the close of the year under review. Mr. C. C. Ghosh was granted a personal scale of pay of Rs. 200—5—250. Mr. D. Nowroji was on privilege leave from 25th October to 20th November 1915. G. D. Ojha and D. P. Singh, Fieldmen, were employed in the Central Provinces, from the commencement of the year to 9th October and from August to November respectively, in connection with the outbreak of "Maho" (*Nephotettix bipunctatus*).

At the close of the year, volunteers were called for for Fly Control work with the Expeditionary Forces in Mesopotamia. T. V. Subramania, Typist, and P. Narayanan, Artist, of this Section, together with D. P. Singh, Fieldman, on the staff of the Imperial Pathological Entomologist but actually employed in Entomological Section, volunteered and were selected and sent. A quantity of apparatus and four sprayers were also sent to Mesopotamia in compliance with indents received from the Army Department.

II. TOURS.

The Imperial Entomologist was on tour in Madras from 18th August to 4th September 1915, in Coorg from 10th October to 23rd November, in the Central Provinces from 14th to 22nd March 1916, and in the North-West Frontier Province from 16th April to 20th June, a total absence from headquarters of 139 days.

Mr. C. S. Misra, First Assistant, visited the Central Provinces and Berar from 3rd to 26th October 1915 in connection with the outbreak of "Maho" (*Nephotettix bipunctatus*) and to study sugarcane pests.

Mr. C. C. Ghosh visited Ranchi from 9th to 15th September 1915 to investigate a stem-gall disease of rice plants caused by *Pachydiplosis oryzæ*, Wood-Mason.

Mr. M. N. De, Sericultural Assistant, toured in Bengal, to see the Silk Centres, from 11th to 21st July 1915.

The Fieldmen were sent on tour as occasion required throughout the year, chiefly in connection with outbreaks of pests. H. H. Prasad, Sericultural Fieldman, with two spinners and three rearers, was sent to the Madras Peoples Park Fair in December 1915, to show a complete working exhibit of Sericulture from egg to cloth.

III. Training.

Two students from the Punjab were under training in Entomology from the commencement of the year under review to 31st March 1916. Two students were also received for the course commencing on 1st June 1916 and remain under training; of these one was sent by Patiala State, the other is a private student. Mr. Mehdi Hasan, of Hyderabad (Deccan), worked in the Laboratory, from 23rd August 1915 to 27th January 1916, mostly on ants. The short courses in Lac-culture attracted no students during the year; this is probably due, as noted in last year's report, to the publication of a popular Bulletin on Lac-work. In Sericulture three students completed short courses in Eri and Mulberry Silk and three remained under training at the close of the year.

IV. Insect Pests.

The following list shows, under the heading of a few main crops, the more important investigations carried out during the year on various insect pests of crops. Other work is shown under other headings (Life-histories, etc.),

but it is not possible, in a brief report of this nature, to mention, even by name, all the insects dealt with during the year :—

1. Cotton. Experiments, commenced last year, were continued to test the relative immunity to bollworm attack of different varieties of cotton from the United Provinces, the Punjab, Bombay, the Central Provinces, and Madras. With this object in view, two sowings of each variety were made, one planted thickly and the other thinly, and weekly counts of affected bolls have been made separately for each series. The parasites that emerged were counted, recorded, and liberated; their hibernation and alternative hosts were also studied. One unexpected discovery was that there are apparently at least five different species of *Rhogas* which attack cotton bollworms (*Earias fabia* and *E. insulana*); their discrimination may prove to be of practical importance in control of bollworm by means of its parasites. The life-history of *Earias fabia* was worked out and repeated; it will be repeated again for the different seasons of the year. The seasonal colour variation of bollworm moths was also studied and a long series of specimens retained showing range of variation. Studies were also made of the utility of trap crops in connection with control of bollworm. The advantage of sowing cotton as a mixed crop was also studied and these experiments will be continued and the results written up as requisite.

At the end of May 1915, the Director of Agriculture, Punjab, requested the despatch to Hansi of bollworm parasites in order to establish a breeding plot and so facilitate their distribution in the Punjab. Between 7th June and 22nd July 1915, 158 grubs and pupæ of *Rhogas* spp. were despatched from Pusa to Hansi, and after the latter date sendings were discontinued as the parasites were fully established in the experimental plots at Hansi.

2. Rice. A diseased condition of growing rice plants, by which the whole growing stem is converted into a long, white, hollow gall, has long been supposed to be due to

attack by a Cecidomyiad fly, but little was really known about it, although a loss of thirty per cent. or more of the crop sometimes occurs. An outbreak of this disease being reported from Ranchi in September 1915, opportunity was taken to study it and it was found that the gall-formation is caused by a small fly (*Pachydiplosis oryzæ*, Wood-Mason) whose life-history was worked out in some detail, but further observations and experiments are required before the recommendation of control measures on a field scale.

Jassid bugs, locally known as "Maho," under which name are included *Nephotettix bipunctatus*, *N. apicalis* and (in less numbers) other similar species, have become a serious pest of paddy in the Central Provinces during the past two years. To help in investigation and control of this outbreak one Fieldman was lent from Pusa for the period April-October 1915 and a second Fieldman in August-November. Mr. Misra, First Assistant, also visited the affected areas in October to investigate the pest, note the damage done, and assist in control work.

Considerable attention has also been paid to these species of *Nephotettix* at Pusa, as regards their exact life-history, hibernation and alternative food-plants, but so far very little light has been thrown on these points. Numerous attempts to breed *Nephotettix bipunctatus* from the egg in captivity have been uniformly unsuccessful. Grass lands and areas which were under rice last season were frequently bagged and a powerful light-trap was also placed in these areas but, from the beginning of December 1915 up to 26th June 1916, not a single specimen of *Nephotettix* could be found, the first example being found amongst grass on 27th June 1916. There is therefore at present an interval of some seven months in the year, during which we know nothing of the life-history of this insect. Work is being continued.

Specimens of Fulgorid bugs, also found on rice in the Central Provinces, have been identified by Mr. W. L. Distant as *Sogata pusana*, *S. pallescens* and *S. distincta*.

Mealy-bugs on rice at Balasore have been identified by Mr. E. Ernest Green as *Ripersia sacchari niger.*

3. Sugarcane. The work of rearing cane-borers was continued, fresh affected cane, maize, juar, millets, wild grasses, etc., being collected and the borers and their parasites reared out. Several broods of moths, bred from known parents themselves reared in both cane and juar, were also reared to ascertain the variability of certain characters. As material accumulates it seems to become increasingly evident that the cane-borers are two or more species of *Diatræa,* which may occasionally attack juar, maize, etc., and that the normal borer in these cereal crops is *Chilo simplex* which is rarely found in cane. Further collection and study are required of material from all parts of India as the question of identity is of importance as regards control.

From observations made at Tharsa Farm, in the Central Provinces, it seems that there is some possibility of reducing the incidence of borers (in this case principally *Schœnobius*) by varying the time of planting the cane. With this view a small experimental plot of half an acre under both thick and thin varieties of cane was planted by the end of October 1915.

Two Fieldmen were detailed to assist the farm in selection of cane setts for planting in February and March.

Observations on *Pyrilla aberrans* were written up and submitted for publication as a Memoir (now in the press).

The sugarcane Aleyrodid (*Aleurolobus barodensis*) was reported from Tharsa as doing considerable damage to canes in the experimental plots. Measures for control were suggested and a large amount of material was also collected and reared to find out whether any effective parasite was present; but no parasite of any importance was obtained.

Papua depressella has hitherto been noted as boring principally in the roots of cane, being mostly in evidence in the ratoon crop. This year it exhibited a new habit by attacking new shoots of newly-planted cane in the early

part of the hot weather (April-May), causing greater damage than either *Diatræa* or *Scirpophaga*. The external symptom of attack is " dead-heart " as is the case of boring by *Diatræa*, *Scirpophaga* and *Sesamia*.

A series of experiments was carried out on the protection of cane setts from attack of termites, the following substances being tried, *viz.*—Lead Arsenate, Resin Compound, Fish-oil Soap with Resin, Crude Oil Emulsion, and Naphthaline Emulsion. Of these Lead Arsenate proved to be the best. In this connection it may be observed that it is not only the setts themselves which require protection but also the new shoots—in fact, in most cases the shoots are most attacked, being eaten into at the point of exit from the sett. It is of course much more difficult to protect these shoots than the setts and, to achieve this, additional treatment is usually necessary. Further experiments will be undertaken on this line next season.

4. Indigo. During the year two Indigo Pests (Indigo Aphid and *Dichomeris ianthes*) were reported from two factories, Barh Chakia and Tateriah, both in North Bihar. A Fieldman was sent to spray the infested fields with Soap Solution. Two sprayings were given and the effect was reported to be good by the Managers of the factories concerned.

5. Coffee. The year 1915 was marked by a very bad outbreak of Coffee Borer (*Xylotrechus quadripes*) in Coorg. One group of estates in S. Coorg, of about 500 acres, removed approximately 100,000 bored bushes between 1st June and 31st October 1915. The Imperial Entomologist toured in Coorg in October and November to investigate this insect. The beetles began to emerge in the last week of October and were common by the first week of November. Eggs were obtained and hatched out and it was proved that sunshine is not essential to the hatching of the eggs, as stated by former observers. The eggs, which are white, soft, of rather indeterminate shape rather like minute rice-grains, are thrust singly or in little groups (of about 6-8)

inside cracks and under scales of bark of coffee bushes; they are rarely visible, and very rarely laid externally. Experiments were started to ascertain the length of life-cycle, as it has been uncertain whether there are one or two broods in the year. Results will be written up when further information on these experiments comes to hand.

Information was also collected on pests of *Erythrina lithosperma*, which is extensively grown for shade and green-manure on Coffee Estates.

6. Orchard and Garden Pests. A special study has been made during the last three years of Insect Pests of cultivated Fruits, Vegetables and Flowers, and a considerable amount of information has been collected on the insects concerned, their identity, life-history, foodplants, occurrence and control. This information will, it is hoped, be issued shortly as a Bulletin.

Special attention has also been paid to the collection of Fruitflies. A large collection of these was sent to Professor Mario Bezzi, of Turin, last year but was apparently lost in the S.S. "Persia" on return after identification; fortunately, the types of eight new species had been sent direct to the British Museum by Prof. Bezzi. *Myiopardalis pardalina*, the "Baluchistan Melon Fly," was reared at Pusa from fruits of *Cucumis trigonus; it was not hitherto* known to occur except in North-Western India.

An important find during the year was the European Olive Fly (*Dacus oleae*) in wild olives in the North-West Frontier Province. Its occurrence in India was hitherto unknown and it is likely to be of importance in view of the attempts now being made to introduce the cultivation of the European olive in North-West India and Kashmir.

7. Life-histories of Insects. In the Insectary were reared about 200 species of insects which had not been reared before. These included about fifty Coleoptera, of various families, of which there was no previous information regarding their breeding-places and habits. Many interesting facts have been noted in this connection; for example, one Elaterid beetle grub (*Agrypnus* sp.) has now

been living in the Insectary for twenty-one months, its food consisting of Scarabæid and other beetle grubs with similar habits of working under the surface of the soil, most of them damaging roots of plants.

As mentioned in last year's report, *Bruchus affinis* was observed to lay eggs extensively on pea-pods at Pusa in January and February, so that the peas may be infected in the field before being stored. The habits of this beetle have since been investigated more thoroughly. The grubs are brought into the store inside the seeds which are externally quite sound at harvest-time, about the end of January. The beetles begin to emerge from the seeds in August, but they do not become active until about December or January, the majority of the beetles remaining inside the seeds and thus having a chance of being taken back to the field at sowing-time. Seeds from pods on which eggs were laid suffered to the extent of about 50 per cent. of the crop, whilst the remainder of this same crop (after separation of those pods with visible eggs) suffered a damage of only 3-5 per cent., and this was probably due to a small percentage of eggs being passed over. Treatment with Carbon Bisulphide or Naphthaline successfully prevented damage to the peas in store. A simple treatment (immersion of the seeds in water, when those attacked float and the unattacked seeds sink) has been found efficient for separation of the affected from the unaffected seeds and therefore it is possible to avoid liberation of the beetles in the field at the sowing time.

Bruchus chinensis breeds throughout the year in Pulse seeds in store. This insect has been observed to breed in Gram, Mung (*Phaseolus mungo*), Urid (*P. radiatus*), Bakla (*P. aconitifolius*), Kulthi (*Dolichos biflorus*), Lentil, Khesari (*Lathyrus sativus*), Arhar (*Cajanus indicus*), Bora (*Vigna catjang*), and large and medium peas. A small variety of local indigenous pea has been found to be immune from its attack. Eggs are laid on this variety as on others, but the grubs cannot bore or feed in this pea, which is, however, more liable to attack by *Bruchus affinis* in the field.

The work of breeding *Agrotis ypsilon*, referred to in last year's report, was continued in order to find out how it passes through the Hot Weather and Rains (April-September). In the Insectary it continued to breed throughout this period. The moths, however, which emerged in July-August did not lay fertile eggs although they had full chances of mating; possibly this was due to inbreeding under unfavourable conditions; at any rate, fertile eggs were not obtained. But, as it was, the insect bred in captivity until about the time (August) when the moths normally appear in the *tal* lands which are subject to attack at Mokameh. During 1916 an Andres-Maire trap was worked in the Insectary compound at Pusa throughout the hot weather (April-June) to see whether any moths of *Agrotis ypsilon* could be attracted but not a single example was captured. What actually happens under normal conditions remains, therefore, still a mystery. The insect can continue to breed under favourable conditions but we have no evidence that it actually does so: our Insectary experience has yielded no indication of any inclination to pass through the hot weather in any resting stage; on the contrary, breeding was continuous until August. On the other hand no trace of the insect has been found under natural conditions between April and August. The migration theory fits the known facts but as yet remains an unproved hypothesis.

Colonies of *Odontotermes assmuthi*, established in artificial breeding cages (tiles) in the Insectary, died out after about four months, by which time adult workers and soldiers had been obtained. One colony, however, which had been planted out in a cage in the ground in the Insectary compound, could be traced for a whole year, after which it dwindled away; even after this period, however, the queen showed no particular sign of a dilated abdomen.

The habits of *Metriona circumdata*, *Aspidomorpha indica* and *Philemostoma trilineata* were observed throughout the year. The beetles hibernate and live for about six months.

The life-history of *Ancylolomia chrysographella* was also traced throughout the cold weather (November-February). This moth hibernates in the larval stage and breeds continuously in the hot weather.

Two tube-forming Tineid larvæ, *Melasina* sp. and *Myrmecozela leontina*, both with only one brood in the year, were also under observation.

The life-history of *Leucophlebia lineata* (Sphingidæ) was traced throughout the year. The larvæ were noted to hibernate as well as æstivate.

Oides bipunctata (Chrysomelidæ) has been observed to hibernate and æstivate in the egg stage.

Polytela gloriosæ (Noctuidæ) has been observed to hibernate and æstivate in the pupal stage.

The already known habit of larval æstivation in *Mudaria cornifrons* (Noctuidæ) was confirmed by further observations.

In connection with other experiments on *Bactrocera cucurbitæ* (Trypaneidæ) it was noted that this Fruit-fly is capable of living in confinement in the adult state for a period of over three months. Under natural conditions it seems probable that many Fruit-flies live over from season to season in the adult state. It was also noted that stems of Cucurbitaceous plants and galls thereon, caused by Cecidomyiadæ or otherwise, were as favourable breeding-places for these flies as the fruits themselves.

In addition to the foregoing, complete cycles were observed of *Danais plexippus* (on *Oxystelona esculentum*, a new food-plant), *Kolla mimica* on paddy, a Jassid bug on sugarcane leaves, another Jassid on leaves of *Cyperus rotunda* (*Mutha*), *Polia consanguis*, a Halticid beetle on *Anisomeles ovata*, and *Cyrtacanthacris ranacea*.

A few broods from known parents were reared of *Terias hecabe* and *Papilio polytes* to ascertain proportional variation.

Further observations were made on the habits of *Tenebroides mauritanicus*, *Odoiporus longicollis*, *Attagenus*

piceus, Lepisma sp., *Chilo simplex, Laspeyresia pseudonectis* and many other insects. Special attention was paid to leaf-mining Lepidoptera and numerous species, including many hitherto undescribed novelties, were bred out from crops and other plants.

Unsuccessful attempts were made to breed *Nephotettix bipunctatus, Zonabris pustulata, Lytta actæon,* and *Heliocopris bucephalus.*

Large numbers of Fruit-flies were reared out to discover to what extent they are checked by parasites but it was found that the proportion of parasites is extremely low. The only Fruit-fly which is parasitized to any appreciable extent is *Carpomyia vesuviana,* whose larvæ feed in fruits of *Zizyphus jujuba.* About 800 pupæ of this fly were sent to Italy, to endeavour to introduce the parasite there, but owing to postal delays they failed to reach their destination alive.

8. Insecticides. A series of experiments was carried out to test the effect of poisoned sprays on Fruit-flies, the species used being *Bactrocera cucurbitæ.* It was found that a spray of *gur* (sugar) and Lead Arsenate killed the flies in the course of about 36 hours. A similar mixture of *gur* and Lead Chromate, had practically no effect and proved quite useless as a poison.

9. Protection of Timber against Termites. The trials under this heading were continued. Further tests of Powellized wood and of Microlineum were made. Preliminary tests of Sideroleum were made, further tests being held in abeyance pending receipt of more material promised by the Agents of this preparation. Tests of Timborite were put in hand.

10. Grain storage experiments. The storage of wheat, rice and pulses, commenced last year, has been undertaken this year on a larger scale based on the first year's results. In addition, in order to determine the pests of stored products more exactly, over sixty different substances have been placed under ordinary storage conditions for observation of their insect pests.

As a result of the first year's experiments, the lime treatment of rice has been found most satisfactory, the stored rice being rendered practically immune from all pests without impairing the edible qualities. It must, however, be noted that the preliminary experiment was done on a very small scale and further tests on a larger scale are now in hand to check this result. The same remark applies to several other samples of wheat and pulses treated in different ways, and all are being retested on a larger scale. One curious case may, however, be mentioned here as at present it seems rather inexplicable; a jar of wheat grains infested with *Calandra oryzæ* had about half an inch in depth of dry sand spread evenly in a layer over the top of the wheat; in due course the weevils emerged and made their way up through the sand which, however, they seemed unable to penetrate again, and all the adult weevils died and formed a layer on top of the sand, leaving the underlying wheat grains unaffected by any further weevils. At first sight it seemed that the experiment had been successful and that a simple layer of dry sand would form an efficient protection for wheat stored either for sowing or for food; but, on testing, this wheat failed to germinate. It was closed up in a glass jar : but so were other samples, equally, more, and less affected by weevils, and kept in exactly similar jars; yet these other samples germinated successfully.

V. Bees, Lac and Silk.

1. Bees. Experiments with *Apis indica* were continued. The Wax Moth (*Galleria mellonella*) gained entrance to the hives at an unexpected period (December) and destroyed five out of seven colonies; other colonies were procured but these were a little too late for the honey flow.

One colony of *Apis indica* was specially worked (1) to check swarming and (2) to attain the maximum yield of honey. Swarming was checked successfully and the yield of surplus honey was 15½ lb. *i.e.*, about double the ordinary quantity. The result was attained by improved methods

and an adequate supply of ready-made combs at the proper time. Work on these lines will be continued.

Several requests for Frame hives, Comb Foundation and other Bee-keeping requisites, from various inquirers, have been met as far as possible.

No further experiments have been made with European Bees owing to the great danger of introduction of Isle-of-Wight Disease into India. In this connection a word of warning may well be issued to any would-be importers of European bees.

A Bengali Bulletin on Bee-keeping has been written up and will be sent in for publication at an early date.

2. Lac. The emergence of Lac larvæ took place at Pusa on 30th September 1915 and 12th June 1916, and sixty large *Ber* trees were inoculated.

Three Lac Show-cases were sent to the Chandernagore Exhibition, in December 1915, together with copies of the Lac Bulletin (in English and Hindi) for distribution to interested inquirers.

A demonstration in Lac-culture was given to the students from the Sabour Agricultural College who visited the Institute.

No students attended the short courses in Lac-culture.

Numerous inquiries for Brood-lac, etc., were dealt with during the year.

3. Silk. Three students completed short courses in Eri and Mulberry Silk-work and three remained under training at the close of the year. Eri silkworm eggs were distributed to 89 applicants and Mulberry silkworm eggs to 70 applicants. Eri eggs and castor seed were sent to the Agricultural Department in Mauritius, where they arrived safely and have done well. Mulberry and Castor seeds, Mulberry cuttings and samples of different kinds of silk were distributed to numerous inquirers. Instructions for rearing, reeling, dyeing, bleaching, and spinning were given by correspondence. The Univoltine Mulberry silkworm eggs which were sent to Shillong and Muktesar for cold

storage gave satisfactory results on rearing in March, but those sent to Guindy for rearing in October were not successful. Some of the hybrid multivoltine races, which have been under selective rearing during the last four years, were reared on a large scale and gave satisfactory results, the outturn of reeled silk in all cases being superior to pure multivoltine races but inferior to univoltines. Silk Exhibits were sent to the Agricultural Show at Muzaffarpur and to the Exhibitions held at Chandernagore and Madras; a complete working exhibit, showing the whole process of sericulture from the egg to the finished cloth, was sent to the Madras Exhibition and proved a considerable attraction. A rearer was lent to Rewah State to demonstrate Mulberry silkworm rearing and reeling. The services of Harihar Prasad, Silk Fieldman, were placed at the disposal of the Imperial Agricultural Bacteriologist in connection with his work on investigation of Pebrine in Mulberry Silkworms.

A Bengali translation of Bulletin No. 48 (First Report on Mulberry Silk Experiments) was printed during the year, and a second edition of Bulletin No. 39 (Instructions for rearing Mulberry Silkworms) is now in the press. A Second Report on the Mulberry Silk Experiments has been written up. Articles on Mulberry Silk were also contributed to the Bengal Journal " Grihastha."

Visitors to the Silk House included Miss M. L. Cleghorn (on special silk duty under the Government of Bengal), Mr. De Minville, and Mr. H. Maxwell-Lefroy, Imperial Silk Specialist.

Silk pieces, to the value of Rs. 504-13-0, were sold during the year and the proceeds credited to Government.

Some experiments were carried out with *Tricolyga sorbillans*, Wied. (*bombycis*), the Tachinid parasite of silkworms, in connection with its method of oviposition and breeding-habits. The following caterpillars were exposed to attacks of the flies, *viz.*:—Mulberry silkworms (*Bombyx mori*), Eri silkworms (*Attacus ricini*), *Achæa janata*, *Spodoptera mauritia*, *Polytela gloriosæ*, *Cosmophila sabulifera*, *Papilio demoleus*, *Utetheisa pulchella*, and

Diacrisia obliqua, of which the last two are hairy and the others smooth-skinned. The flies were found to oviposit on all the varieties of caterpillars, whether hairy or smooth, but could not breed in other caterpillars so successfully as they could in the silkworms. Flies were actually bred out only from the parasitized larvæ of *Cosmophila sabulifera* but from the experiments it appeared that the flies could, if necessary, breed in the other caterpillars.

VI. Illustrations.

Coloured plates illustrating the life-histories of the following insects were prepared during the year, *viz.*:— *Pachydiplosis oryzæ*,* *Papua depressella*, *Phyllocnistis citrella*, *Chloridea assulta*,* *Kolla mimica*, *Oedematopoda clerodendronella*, *Epicephala chalybacma*, *Terias hecabe*,* of which those marked * are now in press and will be available shortly.

A coloured plate of orange fruits was also prepared for the Agricultural Officer, North-West Frontier Province. Besides the completed coloured plates, a large number of figures, in colour and line, was drawn of various insects and these will be utilized for publications in due course.

There is always a heavy pressure of work to be done by the Artist Staff and our life-history work is constantly handicapped by insufficient artistic assistance.

A list of all the coloured plates of Indian insects, prepared to date, was issued during the year, mainly for the information of Provincial Entomological Staffs. This list shows for each insect whether the coloured plate has been printed and, if published, in what publications it has appeared.

The issue of coloured plates and lantern slides has been continued.

VII. Miscellaneous.

Correspondence. A total of 95 parcels of specimens, mostly of crop-pests, was received during the year for identification and advice, whilst 1,090 letters were received

and 1,422 issued, but all these numbers are exclusive of a large amount of routine correspondence. As the activities of the Section become better known, the correspondence becomes more and more onerous and takes up more time which should be devoted to more productive work.

VIII. Insect Survey.

Steady progress has been made in additions to, and arrangement of, the collection. The whole of the collection of Lepidoptera has been overhauled, rearranged and placed in one series, so that all the information on any species or group is now available in one place. The same is being done with the Coleoptera, which are nearly finished, and other groups will be taken up as time and staff permit. Work of this sort takes time and care, but is necessary as, in the not infrequent case of non-identification or misidentification of an insect at the time of its collection or occurrence as a pest, the specimen itself forms the only evidence of its identity and if it is hidden away, out of the series, as a "duplicate" or "non-identifiable," valuable information may easily be overlooked.

The collections continue in good order but the difficulty of maintaining them, in boxes in open racks in a climate such as that of Pusa, is very great.

The following collections were sent out to Specialists in the groups named and our thanks are due to them for the help afforded :—

(*i*) Micro-Lepidoptera to Mr. E. Meyrick, F.R.S., to whom special thanks are due for his examination of the whole of our unnamed material, of which about forty per cent. proved to be new to Science. The novelties are under description in "Exotic Microlepidoptera." A Memoir on life-histories of Indian Microlepidoptera, comprising all the information published hitherto together with a mass of new material now rendered available by the identifications received, is now in preparation.

(*ii*) Rhynchota to Mr. W. L. Distant. Much of the new material has been utilized in Volume VI of *Rhynchota*, lately published in the "Fauna of British India" series. Some of our material has been received back.

(*iii*) Rutelidæ to Mr. G. J. Arrow, who will use this material for his "Fauna" volume on this group. Specimens returned, named.

(*iv*) Carabidæ to Mr. H. E. Andrewes, who is working on the Indian species of this group. Partly returned, named.

(*v*) Trypaneidæ to Professor Mario Bezzi of Turin. The specimens were named and we were advised of their return, but they have not been received and were presumably lost in the S.S. "Persia." Types of eight new species had fortunately been sent direct to the British Museum by Professor Bezzi.

(*vi*) Parasites of Trypaneidæ to Professor Silvestri, Portici, Italy. Not yet returned.

(*vii*) A Dryinid parasite on nymphs of *Pyrilla* spp. to Mr. J. C. Crawford. Named as *Chlorodryinus pallidus*, Crawf.

(*viii*) Cecidomyiadæ to Professor E. P. Felt. They have been named and the collection retained for the present.

(*ix*) Sphegidæ to Mr. Rowland Turner. Not yet received back.

(*x*) Apidæ to Mr. G. Meade-Waldo, whose recent untimely death has deprived us of a most valued correspondent who was always willing to give us every help in identification of our specimens. This collection remains at the British Museum and will probably be transferred to Professor Cockerell for examination.

(*xi*) Curculionidæ to Mr. G. A. K. Marshall. Partly named and returned.

(*xii*) Cerambycidæ to Mr. C. J. Gahan. Not yet returned.

(*xiii*) Histeridæ to Mr. Lewis. Not yet returned.

(*xiv*) Coccidæ to Mr. E. Ernest Green. Partly named and returned.

(*xv*) Diptera (various groups) to Mr. E. Brunetti, who has taken much time and trouble in affording us help.

(*xvi*) Towards the close of the year the manuscript of a paper descriptive of a collection of Indian Termites, sent in 1912-13, was received from Professor Nils Holmgren, of Stockholm. This paper is written in German and will require translation before publication. It contains descriptions of numerous new species and the issue of these will enable a mass of notes on these species to be written up for publication.

(*xvii*) Examples of *Stibaropus minor*, Wlk., found in an Ant's nest were sent to Mr. Donisthorpe, who, however, considered that they were not myrmecophilous insects.

(*xviii*) A collection of *Rhogas* spp. was sent to Mr. C. T. Brues, United States of America, for identification and description of the new species.

(*xix*) A mite found attacking the cocoons of a Burmese Ant, *Ectatomma coxale*, was sent for examination by Mr. S. Hirst, who writes that it is a new species of the genus *Urodinychus*, Berlese. Some species of this genus are known from Europe, a few from Africa and one from Java, and of these some have been found in ants' nests but very little is known about their habits.

Various collections of Indian insects have been received and named and returned as far as possible; these included (*i*) a collection of Rhynchota from Mrs. Kilby, (*ii*) Microlepidoptera from Coimbatore Agricultural College, (*iii*)

insects from birds' stomachs sent by the Nagpur Museum, (*iv*) various insects from Nagpur Agricultural College, (*v*) various insects from Entomological Assistant, Burma, (*vi*) collections of Hymenoptera, Lepidoptera, and Rhynchota from Mr. C. Inglis, besides numerous other small sendings.

IX. Programme of work for 1916-17.

Major.

This will follow generally on the lines of work of the current year and will include general investigations of crop pests and especially of the pests of rice, sugarcane and cotton, of fruit-trees and of stored grain.

Minor.

A commencement has been made of collection of information for a general book on the crop pests of India and progress in this will be continued, as also in the publication of information regarding life-histories of pests and coloured plates, of which a large number are now ready for printing. Work and experiments in silk, lac and bee-keeping will be continued, and new insecticides and insecticidal methods tested as occasion arises. Advice and assistance will be given as far as possible to Provincial Departments and to all inquirers on entomological subjects.

X. Publications.

The following publications have been actually issued during the year :—

De, M. N. . . . Instructions for rearing Mulberry Silkworms. [*Bulletin 39 (Revised Edition), Agricultural Research Institute, Pusa.*]

Fletcher, T. Bainbrigge. Bees and the Fertilization of Coffee. (*Bulletin 69, Madras Department of Agriculture.*)

Fletcher, T. Bainbrigge. One Hundred Notes on Indian Insects. (*Bulletin 59, Agricultural Research Institute, Pusa.*)

Fletcher, T. Bainbrigge. Report on Agricultural Entomology, 1914-15. (*Board of Scientific Advice Annual Report.*)

Misra, C. S. . . Report on Investigations regarding the Maho (*Nephotettix bipunctatus* and *N. apicalis*) in the Central Provinces, October 1915. (*Central Provinces Department of Agriculture.*)

REPORT OF THE IMPERIAL PATHOLOGICAL ENTOMOLOGIST.

(T. BAINBRIGGE FLETCHER, F.L.S., F.E.S., F.Z.S.)

I. CHARGE AND ESTABLISHMENT.

Mr. F. M. Howlett, B.A., F.E.S., Imperial Pathological Entomologist, was in charge of the section from 1st July to 28th July 1915, after which he proceeded on six months combined leave, afterwards commuted into leave on medical certificate and extended by a further period of six months. Mr. B. Coventry, C.I.E., Agricultural Adviser and Director, was in charge from 29th July to 8th August, and the Imperial Entomologist was in charge of the work, in addition to his own duties, from 9th August to the close of the year (30th June 1916).

Mr. P. G. Patel was absent on privilege leave from 3rd to 22nd January 1916, Mr. H. N. Sharma from 8th to 20th December 1915, and Mr. S. K. Sen, from 25th October to 4th December 1915.

In response to a call for volunteers for Fly Control work with the Expeditionary Forces in Mesopotamia, Messrs. Patel and Sharma volunteered their services at the close of the year and have since proceeded.

Tours. Mr. P. G. Patel visited Kathgodam and Bareilly from 12th September to 23rd December to collect and study biting flies in connection with the Imperial Bacteriologist's experiments on Surra transmission.

Mr. S. K. Sen toured in Madras and Bengal from 21st July to 12th September 1915.

Correspondence. The number of letters received and issued during the year amounted to 211 and 228 respectively, whilst 151 parcels of specimens were also received and dealt with. Most of these parcels were of maggots causing myiasis in domestic animals, but several lots of mosquitos, ticks, etc., received for identification, were dealt with.

II. Work done. Disease-carrying insects.

Cattle Flies.

Observations were continued on the life-histories of various Tabanidæ occurring at Pusa. As regards the feeding-habits of Tabanid larvæ it was noted that cannibalism is not universal; at least, so far as observed, larvæ of *Tabanus nemocallosus* do not attack and destroy one another. Forty nearly full-grown larvæ of this species were collected and confined in a very small glass vessel, with some moist earth, but actual counts made twice weekly discovered no larvæ missing or damaged. Of these larvæ, collected on 27th January, only a very few emerged as flies in March, the majority in April and May, and a few in June. The pupal period is eight or nine days. One larva kept under submerged conditions lived for over three months in water without any food; these larvæ must therefore have a respiratory system fitted for both aquatic and terrestrial life and can exist over a considerable period if conditions are unfavourable. Egg-masses of *T. nemocallosus* were found fairly commonly from the third week in April; this species appears to be rather gregarious in its egg-laying habits, depositing its egg-masses by preference on *Phragmites*. The newly hatched larvæ are also gregarious in habit, often noted to be crowded up in a mass in one place in the breeding vessel. Grown larvæ are also more or less gregarious, as on one occasion 63 grown larvæ were collected in one small area of about two square yards, such density of population being only possible if a non-cannibalistic habit is usual. As regards the feeding habits of the adult flies of *Tabanus nemocallosus* it was found that when bred females, starved under humid conditions for twenty-four hours after emergence from pupa, were allowed to bite, under cover of a test-tube, a goat whose skin had been shaven and moistened a little before they were placed to feed, all of them were observed to suck blood within five minutes; in the case of other Tabanids, various observers

have commented on the difficulty in inducing bred females to suck blood (see Patton & Cragg, *Text-book of Medical Entomology*, page 295).

Tabanus albimedius. Flies emerge about the end of February. Egg-masses of this species were observed along the river bank by the middle of March. Egg-laying is at its height thence onwards until the middle of April, whilst very few egg-masses could be found after the beginning of May. A second brood of this fly emerges about the end of June and a third brood in October, the descendants of these again appearing in February-March. These eggs are parasitized by a small chalcidid, of which 166, 78, 105 and 138 individuals emerged from four egg-masses; these parasites were bred and the life-cycle from egg to adult noted to be eight days in the case of males and nine days for females; the males, which are yellowish and smaller than the black females, thus emerge one day earlier and move about on the parasitized egg-mass in eager expectation of the emergence of the females; on this happening, coupling commences immediately and oviposition follows a few hours later. Sixty parasites were bred from one fresh egg-mass of *T. albimedius* after this had been subjected to the oviposition of one fertilized female parasite; the total number of eggs, which may be laid, may, however, be larger, as indicated by the number of parasites reared from individual egg-masses.

Egg-masses of *T. nemocallosus* were also noted to be subject to attack by a parasite of a different species, but no parasites were found in egg-masses of *T. bicallosus.*

Tabanus striatus seems to have three broods annually as in the case of *T. albimedius*, the flies emerging about the end of February, June and October.

Tabanus sanguineus, on the other hand, was not observed on the wing until the end of May, and *T. hilaris*, which is common during the Rains, also did not appear until the end of May.

Chrysops stimulans oviposits on grass growing in shallow water by a river bank during the last week in

March and during April; oviposition seems to take place only between about the hours of noon and 2 P.M. The eggs of this *Chrysops* are smaller and thinner than those of *Tabanus;* they are arranged in a single layer, forming a compact mass; the process of oviposition is almost the same as in *Tabanus*. The new-laid eggs are creamy-white, later changing to pale-brown and ultimately to fuscous; they hatch after 7 days (1-30 P.M. on 22nd March to 8 A.M. on 28th March). The larvæ, like those of *Tabanus*, wriggle out from the eggs and very soon drop into the water. The larva appears sluggish but readily shams death, by bringing together both ends of its body, even at the slightest contact of the vessel in which they were kept; this habit seems characteristic of larvæ of this genus but not of other Tabanid larvæ. The newly hatched larva is about 1 mm. long and has a white syphon-tube which as well as the last segment, is clothed with very minute hairs; all body segments, except first and last (syphon), with a pair of very small delicate bristles on lateral margin; the first body-segment has two pairs, whilst the syphon carries about three pairs apically; Gräber's organ marked by two black dots. After a week, little change is visible except that Gräber's organ is marked by two pairs of dots, posterior pair smaller. Larvæ three weeks old measured 3 mm. long by 0·7 mm. broad, and Gräber's organ had seven black dots, six paired and one single. Larvæ one month old were 5 mm. long by 0·75 mm. broad, and the whole body had developed a pattern on its surface, so that the appearance of the larvæ was quite altered; Gräber's organ had now nine black dots. The larvæ feed readily on dead earthworms and are probably cannibalistic.

Larvæ of *Gastroxides ater*, kept under observation in a small glass vessel, were not found to be cannibalistic. This species breeds in hollows in tree-trunks. The flies sometimes come into light at night (as do several species of *Tabanus*) and are perhaps nocturnal in their habit of flight.

Surra Investigation.

Mr. Patel visited Kathgodam and Bareilly in September-December 1915, to ascertain what kinds of biting flies were prevalent in the Surra Zone and to carry out transmission experiments. A full account of these has been sent to the Imperial Bacteriologist, who will (I understand) publish them with his own results; it is therefore only necessary to give here a short summary of the results attained, *viz.*:—

(1) *Tabanus albimedius* and *T. striatus* were found capable of transmitting the Surra organism, not only by an interrupted feeding, but also by complete feeding.

(2) *Tabanus albimedius* was proved to transmit Surra 24 hours after feeding on Surra-infected animal; it failed to transmit disease after a longer interval. *T. striatus*, however, was found capable of transmitting Surra (in one experiment with two flies) as long as 72 hours after feeding on an infected host.

(3) Smaller species of Tabanus (*T. sp.* near *virgo*) were tried but not found to transmit disease.

(4) *Ctenocephalus felis*, dog and cattle fleas, were found incapable of transmitting Surra.

(5) *Philæmatomyia insignis* is only capable of transmitting Surra in the case of an immediate interrupted feeding, the maximum interval (*i.e.*, between leaving an infected host and commencing to feed on a previously uninfected animal), for which positive results were obtained, being only seven minutes, although positive results were obtained by direct inoculation of abdominal contents of infected flies as long as 28 hours after feeding on a Surra-infested animal.

(6) Surra is not transmitted hereditarily to the progeny of infected females of *Tabanus striatus*, *T. albimedius*, or *Philœmatomyia insignis*

Mosquitos.

The Mosquito Campaign was continued on the Pusa Estate with considerable success, the reduction in numbers of mosquitos prevalent during the year being in marked contrast to the experience of previous years. Breeding-places were sought out and dealt with, either by filling in (hollows in trees, small puddles, etc.), removal (tin cans, pots, etc., holding rain-water), oiling (large semi-permanent pools) or the introduction of larvivorous fish (more or less permanent pools, wells, etc.). Pieces of bamboo-stem, filled with water, were also placed out in trees and in other likely situations to serve as traps for oviposition of *Stegomyia*, and regularly emptied out and replaced. The following were the principal species found breeding on the Estate during the year, *viz.*, *Anopheles fuliginosus*, *A. culicifacies*, *A. rossi*, *Culex fatigans*, *C. gelidus*, *C. sitiens*, Wied (*microannulatus*, Theo), *Tœniorhynchus tenax*, *Stegomyia scutellaris*, *S. sugens* and *S. gubernatoris*. *Pseudograbhamia maculata*, not previously noted at Pusa, was also found and reared during the progress of this work.

Eleven coloured plates, showing life-histories of mosquitos, were sent to press during the year and will be available shortly, and other plates were completed.

Mr. S. K. Sen carried out a series of experiments on the rôle of blood in the development of eggs in mosquitos, the species dealt with being *Stegomyia scutellaris* for the most part. This inquiry was still in progress at the close of the year but a preliminary report on the results attained has been written up; meanwhile, it may be noted here that, as regards *S. scutellaris*, it has been found that this species (1) may oviposit without having fed on blood, (2) may deposit as many as three batches of eggs after only one meal of blood, (3) a single fertilization will suffice for several batches of eggs.

The collection of mosquitos was rearranged and put in order during the year.

A small collection of mosquitos from Pachmarhi was named up and returned and several other small lots of mosquitos were received and identified during the year.

Flesh-Flies.

In response to a circular to Veterinary officers, a large number of specimens of maggots, causing myiasis in domestic animals, etc., have been received and the flies bred out. A parallel series of observations has been kept up on the attractiveness for various flies, especially those species breeding in septic matter, of meat treated in various ways; the substances tried included Peptone, Hydrochloric Acid, Formalin, Papain with Hydrochloric Acid, Borneol, Vanillin, Sugar, Salt, Mercurous Chloride, Benzine, Lactic Acid.

Ticks.

Specimens of *Ornithodoros savignyi*, received from Madras in 1914, and some more of the same species from Gujarat, were under observation throughout the year. A species, identical with or near *O. lahorensis*, was received from Agra. Both were fed on goats.

III. Programme of work for 1916-17.

The work which can be done will depend on the return of (1) Mr. Howlett, now on extended leave on Medical Certificate up to 28th January 1917, (2) the two Assistants sent to Mesopotamia for Fly Control work. Pending their return work must be largely of a routine character, *viz.*, care and upkeep of collections and records, breeding and observation of Tabanids, Mosquitos, Ticks, etc., continuance of Mosquito Campaign, and affording help to inquirers as far as possible.

REPORT OF THE IMPERIAL AGRICULTURAL BACTERIOLOGIST.

(C. M. HUTCHINSON, B.A.)

I. ADMINISTRATION AND TOURS.

Charge. I held charge of the section throughout the year excepting one month's privilege leave in September and October 1915, when Mr. N. V. Joshi was in charge.

Establishment. Mr. C. S. Ram Ayyer was on privilege leave for two months from 25th April 1916.

Mr. A. N. Bose went on privilege leave for one month and four days from 20th November 1915.

Mr. Hardayal Singh has left this section on deputation to work in the Agricultural Department, United Provinces, for two years, and Mr. Umrao Bahadur Mathur has been appointed in his place.

Tours. The following tours were made by me during the year 1915-16 :—

1. July 1915. To Calcutta to carry out experiments on the use of a new form of inoculation for rice beer in the laboratory of the Chemical Examiner, at the instance of the Assistant Commissioner of Excise for Bengal.
2. October 1915. To Shillong on hill recess.
3. November 1915. To Calcutta to consult Director General of Commercial Intelligence Department, on the subject of saltpetre industry, Messrs. Graham & Co., on the subject of manure supply and Messrs. D. Waldie & Co., Konnagar, on the subject of fermentation.
4. March 1916. To Muzafferpur to be present at a meeting of the Bihar Planters' Association.
5. April 1916. To Simla to consult the Imperial Silk Specialist, in connection with the pebrine disease investigation; to Muzafferpur to address

Bihar Planters' Association Meeting on the subject of the modified method of green-manuring.

6. May 1916. To Bakagaon, Dooriah, Motipur, Mehsi and Bara to inquire into the local methods of *nuniahs* in connection with the saltpetre industry.
7. June 1916. To Saraya, Bara and Peepra factories, in connection with work on Indigo manufacture.

II. Training.

Mr. D. V. Bal, Assistant to the Agricultural Chemist to the Government of Central Provinces, who was under training in this laboratory from 20th August 1914, finished his course on the 17th April 1916 and was allowed to return to his Province.

Mr. S. N. Bose, Bacteriological Assistant to the Agricultural Chemist to the Government of Bengal, is under training in this laboratory from 3rd January 1916.

III. Soil Bacteriology.

Toxins. Work on the lines indicated in the report of this section for the previous year was continued, but was considerably interfered with by the claims of special enquiries on various technical subjects hereinafter dealt with. Considerable progress, however, was made in collecting evidence as to the occurrence in field soils of toxins resulting from bacterial action, and of their unfavourable influence upon fertility as dependent upon nitrification and correlated bacterial processes in soil. A series of field experimental plots under wheat demonstrated the production of infertility in soil containing nitrogenous organic matter (oil-cake) as a consequence of semi-anaerobic conditions artificially induced by water-logging; this infertility did not occur to the same extent when ammonium sulphate was substituted for cake, nor did the effect of the water-logging become apparent until the roots of the plants had gone down some inches, to that level in the soil which

oxidation consequent on the cultivation, had failed to reach. Parallel plots with barley illustrated this effect more markedly than those with wheat, no doubt owing to the later formation of the secondary root system in the former crop and its consequent dependence for a longer period of its early growth upon the original deeper roots. Laboratory work on nitrification and on the growth of seedlings in water and soil cultures demonstrated the possibility of separating substances from certain bacterial cultures, from decomposing organic matter and from anaerobically incubated soil, whose toxicity to nitrifiers, and in greater concentration to seedling plants was demonstrable under these conditions.

Interesting observations were made as to the interference with the growth of seedlings resulting from the bacterial invasion of the unexhausted and still attached seed and the consequent absorption by the plant of toxic bacterial by-products. This invasion occurred most readily in water-logged soil and more especially in the presence of bacteria derived from anaerobically incubated soils of high organic matter content. Copper sulphate was found to neutralize most of the toxic bodies obtained in this way, and seeds treated with this salt were found to be immunized to some extent, although not entirely or invariably, against this action. It is suggested that some such treatment might be advantageous when sowing in wet soils, although the results of field trials have so far not yielded conclusive results, owing to the difficulties associated with its use and the unfavourable effect upon germination which copper sulphate has been found to exert in many instances.

Amongst soil toxins produced by bacterial action nitrites are well known to exert a prejudicial effect upon plant growth; it has been found that their presence in soils is not alone due to the reduction of nitrates already formed, although this is of frequent occurrence, but that in many of the soils examined in this laboratory nitrites accumulate to some extent before nitrate formation becomes evident, even under conditions apparently favourable to nitrification.

It is not clear at present whether this is due to the formation and reduction of nitrates or to incomplete oxidation consequent on the lack of activity or insufficient number of nitrate formers in the soil. Evidence is not wanting that in many of the soils examined the very slow rate of nitrification observed under optimal conditions of aeration and water content, is due to the absence in sufficient numbers or lack of physiological activity of the necessary nitrifying organisms. It will be readily realized what an important field for enquiry is opened up by this observation, which, however, in view of its wide divergence from received ideas on this subject, will require further substantiation by careful experiment and observation. The effect of nitrites on seedlings and the concentration required to produce the prejudicial results observed, was ascertained for various field crops in water culture. At the same time observations were made as to the concentration of nitrites occurring in the soil water under various conditions, but in none of the soils examined was this found to rise to the degree found toxic in water culture. It does not necessarily follow that this statical treatment of the question disposes of the possible intoxication by nitrites of plants growing in such soils, owing to the necessity for taking into account the constant formation of nitrites in the soil to replace those absorbed by the plant or oxidized in the soil, and the possibility of cumulative intoxication in the plant itself of which at present we know nothing. The presence of nitrites in soil was found to affect germination and early growth; this explained the apparently anomalous result of an experiment in which germination in a well-aerated soil compared unfavourably with that in the same soil badly supplied with air; on further examination it was found that in this soil when well aerated complete nitrification was preceded by the incomplete stage of nitrite formation and accumulation, and as this was coincident with the germination period of the seeds sown therein the germination of the latter was interfered with to a greater extent than in the soil in which no nitrification was taking place.

Weekly borings and nitrate determinations throughout the year were made in three sets of duplicate plots under grass, cold weather and rains crops (wheat and maize), and fallow respectively. Only in the last of these was there any accumulation of nitrate in the first foot of soil, a much smaller amount occurring in the cropped soil and only very small quantities under grass. Experiments will be made to ascertain whether the grass effect is due to interference with the upward movement of water resulting from evaporation from the surface, to lack of aeration, or possibly to the toxic action of the specific bacterial flora associated with the grass plants. The nitrate accumulation was highest in February and reached a minimum in August; this was only in the first foot of soil and no doubt represented the vertical movement of nitrates parallel with that of the soil water.

Green-manuring. Experiments with fermented green manure were carried out on tobacco to which fermented sann hemp (*Crotalaria juncea*) was applied. Very large increases in yield were obtained, and a Bulletin (No. 63) describing this modified method of manuring was published, inviting suggestions and criticisms from agricultural officers in the Provinces from whom many useful and appreciative communications have been received, pointing out the applicability of the method to various manurial problems and special cases in their several districts. It is hoped that the experimental trials of this method which are now being made throughout India may lead to more satisfactory and certain results from the use of green manures than are generally obtained. A field trial of the method at Pusa carried out by the Imperial Agriculturist on the *rabi* oat crop gave very high returns : the Officiating Imperial Agriculturist is carrying out a further experiment this year.

Saltpetre. The enquiry into the conditions favouring the occurrence of saltpetre in Indian soils and the methods adopted by the native for extracting it, was continued and the results published in a Bulletin.

It was concluded that the output of saltpetre is limited at present not so much by the available supply of raw material, as by the number of workers (*Nuniahs*) actually engaged in extraction, this being largely determined by the price of crude saltpetre and the restrictions imposed by landholders, refiners, and the Salt Department. No special soil organisms appear to be associated with saltpetre deposits which are the result of the nitrification of organic matter accumulated in the neighbourhood of human dwellings, the high concentrations of nitrate found in the soil in such sites being due to the upward movement of water carrying dissolved nitrates to the surface where they become concentrated by the intense evaporation going on during the dry months of the year. Experiments on a field scale showed the feasibility of adding to the store of nitrates in the country by the use of nitre beds made up by burying a green crop, in this case *Crotalaria juncea*, in ordinary field soil and compacting the heaps sufficiently to ensure the capillary rise of water from the subsoil to the surface, where the nitrate formed accumulates and can be scraped off after the manner of the *nuniah*. It is suggested that a very large output of saltpetre could be obtained in this way in those parts of India in which soils with sufficient lime content and suitable physical texture are found. At the same time the condition of the industry as a whole could be greatly improved by the introduction of better relations between the *nuniah* and refiner and a revision of the rules of the Salt Department in regard to both of them. It seems clear that the profits of the trade are not equitably divided between the *nuniah* and the refiner, the former class, in consequence of its poverty and lack of business capacity, being entirely at the mercy of the middleman or refiner to the detriment of the industry as a whole. So far as the methods of extraction and refining are concerned the work of the Chemical Section of this Institute, as described in Bulletin No. 24 by Messrs. Leather and Mukerji, has demonstrated the possibility of great improvement in the refining part of the process, and further investigation in

the writer's laboratory has shown that the *nuniah's* method of extraction of the crude saltpetre is far from being economically sound, and could be greatly improved upon by some simple variation of his present technique, which would, however, probably depend upon co-operation with the Salt Department in order to avoid infringement of the regulations at present in force. An advantage offered by the artificial method of producing saltpetre above referred to, lies in the comparative freedom from contamination by salt (sodium chloride) of the crude saltpetre resulting from this method, thus avoiding to a great extent in the process of extraction the restrictions necessarily imposed upon this process by excise requirements, with a consequently higher return of pure product to the advantage of the *nuniah* and the trade.

IV. Special Enquiries.

Fermentation Organisms. Further work on alcohol producing organisms, and upon various problems in connection with Indian distilleries was carried out at the request of the Departments of Excise in Bengal, Bihar and Orissa, Assam and Central India, and of private firms in various parts of India. Improved methods of obtaining and utilizing yeast cultures of indigenous origin were experimented with and gave promising results. The use of mixed cultures of good types of *S. cerevisiæ* of Indian origin was reported by the Commissioner of Excise for Central India to have given an increased yield of some 20 per cent. in the Nowgong Distillery, and the method of re-inoculation devised in this laboratory was found to give considerably higher yields of alcohol in the same period of time and should therefore be of value in avoiding the evil effects of the acetic fermentation which generally sets in towards the end of the process.

Numerous other problems connected with fermentation were studied, but it is clear that a good case exists for the establishment of a special laboratory in India for the investigation of such questions, both for the isolation of

good strains of yeast and for the training of distillers' assistants in their proper use.

Pebrine. At the request of Mr. Lefroy, Imperial Silk Specialist, an investigation of the conditions of incidence of this disease of silkworms in India was undertaken. The primary object of the enquiry was to determine whether the failure to avoid disease in India by using the Pasteur method of selection of disease-free "seed" is due to any inherent inapplicability of the method to Indian conditions, or merely to its improper use in this country. So far as the enquiry has proceeded it appears that both these factors come into play in Bihar and Bengal. The Pasteur method depends upon the examination of the parent moth and the rejection of eggs from those found infected; the standard method of examination devised by Pasteur and used with success in Europe but with less certainty in India, allows of microscopic examination of a drop of the fluid obtained by crushing the whole moth without distinction of parts, it being assumed that the disease producing pebrine bodies will exist in such numbers in the diseased insect at this stage of its growth as to make certain of their occurrence in any sample of the body fluids taken for examination. This, however, has not been found to be the case with the pebrine-infected moth of the multivoltine mulberry silkworm as used in this part of India. Examination in the ordinary manner in many cases has failed to find the pebrine bodies, whereas examination of the lining tissues of the intestine of the same specimens has revealed their presence, the diseased condition being subsequently confirmed by the development of pebrine in a high percentage of the larvæ reared from the eggs of the moths so affected. It is clear therefore that in India, the standard method of examination fails to eliminate all diseased eggs, and in order to be at all certain of this being done it will be necessary to alter the method and unfortunately to make it more difficult and more laborious, although not at all outside the range of capability of the class of workers at present engaged in selection. In parts of Bengal, the con-

ditions are rendered more difficult by the unalterable prejudice of the rearers against purchasing "seed" in the form of eggs, their desire to be assured of the quality of the silk to be obtained leading them to refuse to buy anything except live "seed" cocoons. This means that eggs derived from moths which have passed examination and are presumably disease free, must be hatched out and brought to maturity, at the same time going through all the chances of infection incidental to several weeks' life in artificial surroundings, the resulting cocoons possibly re-infected during maturation, being bought by the rearers and used as seed. Until this prejudice is overcome by the establishment amongst the rearers of more confidence in the rearing stations, the industry must necessarily labour under the disadvantages resulting from the chances of re-infection of the seed in the manner above described.

A further point of interest has been investigated and sufficient evidence collected to warrant a certain amount of confidence in the conclusion arrived at, namely that infection of the larvæ so far as pebrine is concerned does not take place at all after the fourth moult, with difficulty after the third moult, but with comparative ease up to this stage in the life cycle. This conclusion is necessarily only a provisional one being based on a comparatively small number of experiments, but should it be confirmed by further observation it will simplify the precautionary measures in rearing by making it possible to relax them considerably during the later stages of growth, when larger quantities of leaf and greater space are required by the worms. Incidentally it was found that the majority of the larvæ were not only able to resist infection altogether when kept under optimal conditions so far as space, air and food were concerned, but that in a large number of cases the progeny of highly pebrinized moths failed to develop disease at all, if reared under these favourable conditions, others from the same brood but in unfavourable surroundings succumbing in large numbers.

Study of the life cycle of the parasitic organisms (*Nosema Bombycis*) is being carried out; so far no marked differences have been observed between the Indian and European forms, but observations are necessarily incomplete at present.

Indigo. At the suggestion of the Indigo Research Chemist an enquiry was undertaken into the bacteriological aspects of the fermentation taking place in the indigo steeping vat. As might have been expected, many important facts in connection with the great variations in yield which are known to occur for no obvious reason were brought to light by this enquiry, which, however, has not yet proceeded far enough to afford any complete explanation of the results obtained. It is clear, however, that the success of the process of manufacture as at present carried out depends primarily upon the presence and action of specific bacteria in the steeping vat, and further that in some cases an adverse result is due to the activity and deleterious influence of others. It is a well known fact that during the earlier days of manufacture the yield of indigo is low but becomes rather suddenly higher, remaining so as long as continued use of the vats persists. Any vats not utilized at first but brought into operation later, exhibit the same phenomenon, clearly showing that the latter is not due to changes in the plant, the water, or methods of manufacture. Well attested cases have been observed of differences in yield of as much as one hundred per cent. or more between head factories and their out-works manufacturing plant grown under similar conditions of soil and climate, and it was possible in one instance to arrange to exchange indigo plant from one such factory to another, thus eliminating any possible influence of this factor, but without altering the previously observed difference in the respective yields. The most obvious conclusion seems to be that such differences are due to the presence or absence of specific bacteria which multiply in and infect the steeping vats, increasing in number and consequently in their influence upon the character of the fermentation up to the limits of the permanent

substratum (in this case the walls and floor of the vat) upon which they remain from one operation until the next; this supposition is supported by observation of the easily verified fact that fermentation commences in the immediate neighbourhood of the walls of the vat and gradually spreads therefrom toward the centre. Here we have an analogy with such functions as that of the "starter" in dairy work and the bacterial slime of the sewage filter bed, and very probably under natural conditions with the micro-organisms responsible for the retting of jute and flax. Many industries depend upon the intervention of micro-organisms, but whereas in some of them the presence of desirable species and the absence of deleterious ones is ensured by artificial measures as in the case of brewing and distilling, in others it is assumed that the proper organisms will be naturally present in sufficient predominance to ensure satisfactory results. This is the case with such native Indian industries as the fermentation of "Toddy" and "Mahua," the retting of jute and the steeping of indigo, but it is becoming daily more clear that the distribution of the necessary and proper micro-organisms is by no means so universal or so fortunate as to carry these and similar operations outside the range of practical artificial regulation.

The enquiry in connection with indigo is at present in too early a stage to warrant any confident assumption that it will be possible to apply the methods of the distillery or the dairy with economic success to a raw material such as the indigo plant, but should further work confirm the conclusions set forth above, it would appear that very considerable improvements in the methods of manufacture may be obtained by artificially ensuring the presence of the necessary organisms in the steeping vat.

It has been ascertained that two distinct types of fermentation may be found in the steeping vats, one in which copious evolution of nitrogen takes place, the only other gas given off being carbon dioxide, and the other in which

hydrogen is liberated in addition to these two. In the former case, during the factory period of fermentation, about twelve hours, nitrogen forms sometimes as much as 98 per cent. of the evolved gases, the remainder being carbon dioxide; later these proportions are slowly reversed, but this reversal is of no importance as not affecting factory conditions and requiring 48 hours to 60 hours to complete.

In the second case the evolved gases after twelve hours are composed of about equal parts, some 33 per cent. each of nitrogen, hydrogen, and carbon dioxide. It is remarkable that no trace of methane has been found in any of the numerous fermentations carried out, and it is also of great interest to note that in some instances in contradistinction to the high nitrogen evolution frequently found, very small quantities of this gas were evolved.

It is clear therefore that the character of the fermentation must be governed by that of the bacterial complex fortuitously present, and that this may vary essentially and profoundly even in contiguous localities. This variation will have a special interest and importance in connection with the decomposition of organic matter in soil under varying conditions, and must be taken into careful consideration in advancing any theories based upon observation of chemical changes due to bacterial action in soils under otherwise apparently similar conditions.

Numerous species of bacteria have been isolated in the course of this enquiry and their physiological activities with regard to the processes of fermentation investigated. It has been possible to place some of them definitely either in the class of beneficial or deleterious organisms, but much further work will have to be done before their true functions in this connection are fully understood. It is of interest to note that one bacterium has been identified with the unfortunate condition which sometimes arises in the "beating" or oxidizing process known as "green vat."

Biological analysis of soils. Numerous samples of soil from various districts were analysed by the biological

method elaborated in this laboratory. Familiarization with the use of this method forms an important part of the training of students in this section and as such students mostly come from the laboratories of Provincial Agricultural Colleges and return there as assistants to the experts engaged in soil investigation, it is hoped that in course of time the method may be adopted as a standard part of such enquiries throughout India.

V. Programme of work for 1916-17.

Major subjects.

1. The decomposition of organic matter in the soil by bacterial action.

2. The formation of toxins in soil and their relationship to fertility.

Special enquiries.

3. *Saltpetre.* Investigation into the conditions under which this salt is formed in the soil with a view to introducing possibly favourable modifications into the present methods of the *nuniah.*

4. *Fermentation.* Further inquiries with regard to fermentation organisms in India.

5. *Silk.* Pebrine disease of silkworms in India; an enquiry into the incidence and underlying causes of this disease undertaken at the request of the Imperial Silk Specialist.

6. *Indigo.* An enquiry into the bacterial activities associated with the manufacture of indigo undertaken in collaboration with the Indigo Research Chemist.

Minor subjects.

7. Bacterial disease of plants.

8. Biological analysis of soils and elaboration of laboratory technique in connection therewith.

9. Training of students.

VI. Publications.

1. Walton, J. H. — Azotobacter and Nitrogen Fixation in Indian Soils. *Memoirs of the Department of Agriculture in India, Bacteriological Series*, Vol. I, No. 4.
2. Hutchinson, C. M. and Joshi, N. V. — Bacterial Rot of stored Potato Tubers. *Memoirs of the Department of Agriculture in India, Bacteriological Series*, Vol. I, No. 5.
3. Hutchinson, C. M. and Ram Ayyar, C. S. — Bakhar:—The Indian Rice Beer Ferment. *Memoirs of the Department of Agriculture in India, Bacteriological Series*, Vol. I, No. 6.
4. Hutchinson, C. M. — Report on Soil Bacteriology for Board of Scientific Advice, 1914-15.
5. Hutchinson, C. M. — A Modified method of Green-Manuring. *Bulletin No. 63 of the Agricultural Research Institute, Pusa.*
6. Hutchinson, C. M. — Saltpetre—Its origin and extraction in India. *Bulletin No. 68 of the Agricultural Research Institute, Pusa.*
7. Hutchinson, C. M. — Photographic Illustration.—An article in the *Agricultural Journal of India* for July 1916.

REPORT OF THE IMPERIAL COTTON SPECIALIST.

(G. A. GAMMIE, F.L.S.)

I. CHARGE AND TOURS.

Charge. I held charge of the office of the Imperial Cotton Specialist throughout the year.

Tours. In addition to the special investigations which were under continuous observation, I visited Khandesh in September and October; travelled through Central India with Mr. Coventry in November; in December I toured in the Central Provinces; in April I visited the Southern Mahratta Country.

My Assistant Mr. Mankad made special researches during the year in the Southern Mahratta Country, Gujerat and the Garo and the Chittagong Hill tracts.

II. COTTONS IN THE PROVINCES.

Central India.

The following report was submitted to Mr. Coventry with whom I made a tour throughout the cotton tracts of Central India :—

" Gwalior is not really a cotton tract and for the purpose of improving what little cotton there is, the trials of the following would be sufficient :—

(1) Yellow-flowered Malvensis.
(2) White-flowered Roseum.
(3) Cambodia under the control of irrigation.
(4) Leake's K 7, on account of its earliness.

" At Bhopal, white-flowered cottons do not seem to come in the mixture of varieties and the higher quality of the local cotton is due to this fact. The cotton round Bhopal, 5,000 bales, is said to be capable of spinning 20's. It has a percentage of 25, which is far too low.

" I am of opinion that the Malvensis or the Malvi cotton is really the only high class cotton of the Malva tract and if that were purified, no foreign variety could possibly surpass it in excellence.

" As regards Central India, I would recommend that the following trials should be made in as many cotton areas as possible :—

(A) For high class soils—

(1) Local Malvensis.
(2) *Bani* × *Deshi Lahore* from Sindewahi Farm.
(3) *Bhuri* from Akola. } Controlled by irriga-
(4) Cambodia from Gadag. } tion if possible.

(B) For the inferior soils of the Nimari tract—

(1) Local *roseum.*
(2) Akola *roseum.*
(3) K 7.

" From valuations received from Messrs. Tata on various cotton samples sent from the Indore Farm, the so-called local cotton is valued at Rs. 225 and is said to have no characteristic of the cotton of the district. The variety *vera* of the same farm is reported to be characteristic of the cotton of the district and is valued at Rs. 280, the market rate of the day for Indore cotton. It has fair staple, but it is inferior to the Sindewahi Crosses *Bani* × *Roseum* valued at Rs. 285, and *Bani* × *Deshi Lahore* valued at Rs. 295. I had a comparison made specially because I was in search of a better cotton for Central India. I consider that *Bani* × *Deshi Lahore* is in every way superior to Malvensis. As far as appearance goes, there is no tangible difference and the growing period is the same.

" Cambodia, wherever possible, should be started under irrigation early in the season so that it can be ripened before the severe cold weather begins. The true Malvensis of the Central Provinces has been abandoned on account of its low percentage of 32 not allowing it to compete with the coarser varieties of high percentage, but it is quite probable that *Bani* × *Deshi Lahore* will take its place."

United Provinces.

The Deputy Director of Agriculture of the Central Circle submitted for valuation samples from nine selections of acclimatized Cawnpore-American Cotton. All were grown under irrigation. The yield from these, this year, was very unfavourable, being about 560 lb. of *kapas* per acre but in good years the unselected crop gives on the farm 720 to 800 lb. per acre on a large scale and has yielded up to 1,200 lb. per acre. The ginning percentage of these selections is 31 to 33.

Messrs. Tata reported as follows on these samples :—

Basis of prices on 11th July 1916.

	Rs.
Sind-American	310
Good Sind-American	325
Madras Cambodia	365
Ordinary Cambodia	340
Saw-ginned Dharwar	320
Navasari	375
Kumpta	345
Superfine Bengal	250

Samples 1 to 9 : —

Of these No. 2 is the best in length and strength of staple, then comes No. 9, then come Nos. 1, 6, 7 and 8 which are equally long in staple but rather weak in fibre; then come Nos. 4 and 5 and No. 3 comes last.

No. 2 can spin up to 30's, value Rs. 340.
No. 9 can spin up to 24's, value Rs. 330.
Nos. 1, 6, 7 and 8 can spin up to 20's, value Rs. 325.
No. 3 can spin up to 16's, value Rs. 310.

All fibres are irregular.

Central Provinces.

The following report was submitted to the Director of Agriculture together with the remarks and the valuations of certain varieties of cottons which have recently been estimated :—

Sindewahi. Here there are a number of good selections of *rosea*. Mr. Clouston proposes to reduce these to one or two, basing the selection on ginning percentage and acreage outturn, the highest ginning percentage so far being 42.

One sample of *roseum* was reported on by Messrs. Tata & Sons as equal to Superfine Bengal, spinning up to 10's and valued at Rs. 240 per *candy*. The ginning percentage of this variety was 39·9. The outturn was 1,035 lb. seed cotton per acre, so that the actual value of this cotton per acre works out to Rs. 126-6-0.

Cambodia was ripening at the same time as *Bhuri* and not later, as is usually the case.

Messrs. Tata made the following remarks on a sample submitted to them :—

" Cambodia has greatly improved on the Chanda soil. The feel is soft, staple longer and stronger. Value Rs. 350, *i.e.*, equal to the full market value of the day. It can spin 40's." The percentage of cotton to seed was 34·8 and the outturn 534 lb. This gives an actual acreage value of the cotton, Rs. 82-15-0. Bhuri was said to be equal to the above, but with stronger staple, and it is valued at Rs. 355. The percentage was 33·7, acreage yield 492 lb., the value of the cotton being Rs. 75-1-0 per acre.

Acclimatized Allen's Hybrid from Nagpūr looked well and bore a high quality of lint. No sample of the cotton was submitted for examination.

Leake's " K 7 " is a smaller type of plant than any found in the Central Provinces. It is very prolific, being covered with bolls, which are, however, of small size. The percentage of cotton to seed is 32·6, the outturn 920 lb. It is valued at Rs. 250 on account of its softness and slightly longer staple. All the varieties of this type tried in the Jari tract were valued at Rs. 235. The acreage outturn of *K 7* works out to Rs. 95-10-0.

Bani × *Deshi Lahore Cross.* This is very promising, the lint is similar to Malvensis, but the ginning percentage is 35·5 and the yield per acre, last year, was 600 lb. The

possibility of the extension of this type should be kept in view. At present the difficulty of obtaining labour sufficient to put out rice and cotton at the same time precludes the idea of any close attention being paid to cotton, which is not a crop of this tract. When the work of distributing the seed of this variety commences, I have suggested that it should bear the name of *'Sindewahi Cross.'*

Another cross *Bani* × *Roseum* is almost as good as this, but the lint is slightly harsher and coarser. Messrs. Tata & Sons report as follows of these two varieties :—

Bani × *Roseum.* The crossing seems to have improved the original type *Roseum*, the *Bani* having imparted to *Roseum* the characteristic of its staple. The fibre is very strong and the staple fairly long. We value this at Rs. 285 and it can spin up to 20's to 22's.

Bani × *Deshi Lahore.* This is superior to the last in length and silkiness. The crossing has improved the Delhi-Punjab cotton. We value it at Rs. 295. The percentage of *Bani* × *Roseum* is 36 and the yield 920 lb., giving an acreage value of Rs. 119-3-0. The percentage of *Bani* × *Deshi Lahore* is 35·5, the acreage outturn 760 lb. and the value of cotton Rs. 101-8-0.

Placed in the order of their actual outturn value, the varieties sent from the Sindewahi Farm stand as follows :—

(1) *Roseum.*
(2) *Bani* × *Roseum.*
(3) *Bani* × *Deshi Lahore.*
(4) *K 7.*
(5) *Cambodia.*
(6) *Bhuri.*

The bases of the market prices of the day on 15th February 1916 :—

	Rs.
Cambodia	350
Ghat Bani	340
Fine Akola	265
Fine Khandesh	250
Indore	280
Fine Bengal	228
Superfine Bengal	240

Nagpur. I went over the cottons on the Nagpur Farm with Mr. Graham, the Economic Botanist. He is working out an early variety suitable for introduction into the northern parts of the Central Provinces.

The tall growing variety, which I selected out for him, last year, comes quite true. Mr. Allan has discovered what appears to be wilt-resisting Neglectum and this deserves to be thoroughly tested.

Jubbalpore. The experiments here are conducted with the view of evolving a productive early variety for Seoni. The yellow-flowered Saugor Jari is preferred here, on account of its high yield. It has already been introduced into Seoni and the two cotton tracts of the Jubbalpore District. In this yellow-flowered Saugor Jari there are two types of lint, one resembling that of Malvensis, the other Vera. Mr. Graham has picked bolls of each from single plants for further test, as it is clearly necessary to make a more rigid selection of Saugor Jari than has already been done.

In *C 10* there is a distinct evidence of crossing between Jari and Mooltan. The result is promising and Mr. Graham has taken the bolls of one good plant for further test.

Powarkhera Farm. *Saugor Jari yellow-flowered.* Ginning percentage from 36 to 39. The plants were uniform on the whole, being of the Jari or Vera type, with a very slight tendency towards Malvensis.

Saugor Jari white-flowered. Ginning percentage 37 to 40. In appearance it differs a little from the preceding; but there is perhaps not such a strong tendency in the direction of Malvensis.

Aligarh white-flowered. Percentage 38 to 42. Does not appreciably differ from the white-flowered Saugor Jari, though, on the whole, the lint may be coarser; samples of cottons were supplied by the Superintendent.

Messrs. Tata report as follows on the samples sent from this Station :—

Basis of prices per candy of 784 lb. on 15th July 1916 :—

	Rs.
Berar Jari	270
Fine Bengal	240

Aligarh white-flowered. Compared with *roseum* grown on the Akola Farm is almost equal to it except that the Aligarh cotton is softer to the feel. Value Rs. 245.

Saugor Jari yellow and white-flowered are ordinary short stapled Rajputana style cotton. Value Rs. 235.

Akola Farm. Ten samples of cotton received from the Akola Station stand in the following order based on the outturn per acre and valuations made in Bombay :—

	Rs.	A.
(1) Bhuri	116	10
(2) Cutchica	104	6
(3) Roseum	100	15
(4) Bani	76	8
(5) Berar Jari	74	11
(6) Bani × Deshi Lahore	73	2
(7) Vera	57	11
(8) Malvensis	45	10
(9) Bani × Mathio	37	14
(10) Bani × Roseum	35	15

Bombay.

Jalgaon Farm. Mr. Leake's *K 7.* The plants are uniform, about 2 feet in height and fruit freely from base upwards and every plant ripens a good number of bolls. This variety came into flower on the 10th August and the picking is expected in the first week of October. The picking of the local cottons will commence in the third week of October. The cotton of *K 7* is slightly superior to that of the N. R., but the percentage is low. Owing to its early ripening it ought to be sown a fortnight later than the N. R. in order that it may not be spoiled, when ripening, by rains. This might be tried in the lighter rain-fall area of Dhulia where the crops are all in, by December.

The sample of the cotton was valued by Messrs. Tata at Rs. 235 and it was reported to be quite similar to the

cotton of N. R., which was valued Rs. 5 lower. The outturn of K 7 is 525 lb. with the percentage of 33·25 against an outturn of N. R. of 657 lb. with the percentage of 38·12.

K 7 ought to be again tested this year, but unless its percentage improves, it will not compete with N. R.

N. R. Narrow-lobed, white-flowered—a seed rate of 7 lb. per acre has given a very good stand of plants with correct spacing. The usual seed rate on the farm is 11 lb. and the cultivators give 17 to 18 lb. The whole of the cotton on this farm is N. R.

Last year, 100,000 lb. of this was distributed. This year East Khandesh alone has taken 50,000 lb. There is a variation in the percentage of this cotton grown in different tracts and this variation may be due to slight differences of soil and rainfall. Mr. Kulkarni holds that the better the soil, the higher is the percentage and Mr. Vagholkar says that the longer the growing season, the better is the lint. The average percentage on the Tapti side of cultivators' cotton is 39·5, and on the farm it is 38·1. Experience gained at Dhulia proves that this cotton may be grown seven years in succession with no deterioration in quantity or quality. In future operations, selection work should go on steadily with a view of increasing the ginning percentage. The sample of cotton was valued at Rs. 230, while cotton from the same variety in the Central Provinces was valued at Rs. 240.

The average acreage values of N. R. and K 7 are Rs. 75-0-0 and 51-2-0 respectively.

Dharwar and Gadag Farms. The following report on the inspection of cottons at Dharwar and Gadag and the valuations of the samples received from the same places was submitted to the Director of Agriculture :—

Dharwar. Broach in its 10th generation maintains the ginning percentage of 32 to 33 and its period of ripening is intermediate between Kumpta and Broach.

Three samples of Broach were submitted to Messrs. Tata & Sons for valuation, one from the newly imported seed

was valued at Rs. 360; one of the 10th generation at Rs. 345 and one of the 12th generation at Rs. 330. They remark that this shows that freshly imported seeds sown on the Dharwar Farm show good results, but as the seeds get old the cotton becomes deteriorated. (Navasari of the day quoted at Rs. 365.)

In the Broach cotton auction held at Dharwar the crop was divided into five grades based on the percentage:—

1st class	33·5
2nd class	32·5
3rd class	31·5
4th class	30·5
5th class	29·5

One sample of each was remarked on as follows by Messrs. Tata:—"All the 5 samples are almost alike having very long staple, strong fibres combined with softness and silkiness. They can all spin up to 40's; value Rs. 375 equal to the Bombay market rate of Navasari for the same day and Rs. 345 for Kumpta." Messrs. Tata suggest that the cultivation of such cottons should be encouraged as much as possible; as from the several samples they have examined they find that the cotton grown in the Dharwar District out of Navasari seed is the only cotton that shows such uniformity and maintenance of strength and length of fibre.

Kumpta. The cultivator's sample of Kumpta cotton was valued as equal to the best Kumpta cotton grown in the district. It would spin up to 30's and it is priced at Rs. 335 equal to the Bombay market rate of Kumpta on the same day.

The ordinary Kumpta of the Dharwar Farm is almost equal to the last but is a little more silky, value the same and it can also spin up to 30's.

I would suggest that at Dharwar, the testing of the generations of Broach should be continued although it is fairly obvious that they soon deteriorate in value; new seeds should be introduced and tested yearly, and special atten-

tion should be given to any admixture of varieties that may occur as there is a suspicion that Broach seed is not so pure as it was.

In Kumpta, the test for quality and quantity should be continued and in the crosses, *Kumpta Cross* No. 1340 and *Kumpta* × *Ghogari* No. 1364 should be grown on as large a scale as possible.

As the list of varieties has grown to a great length it would simplify matters if the least promising were thrown out.

Gadag Farm. A sample of Dharwar-American of the farm was valued at Rs. 320, it can spin up to 20's.

A sample from Ranibennur is superior to the former in length of staple but the cotton is thin and fluffy having more wastage; it was valued at Rs. 310.

The cultivator's sample is the worst of the lot having very short staple and dull colour. It is valued at Rs. 300 and can spin up to 12's.

Of three samples of Upland type of cottons there is very little difference. They are all bulky and good stapled cottons. Nos. 4 and 5 can spin up to 32's and No. 6 up to 20's; Nos. 4 and 5 are valued at Rs. 335 and 6 at Rs. 330.

Of the three samples of New Orleans cotton, they are all thin and inferior to Nos. 4, 5 and 6. They can spin from 18's to 20's. Value Rs. 315 for No. 7 and 310 for Nos. 8 and 9.

Allen's Hybrid selected for quality and quantity—both samples are better than ordinary Saw-ginned Dharwar-American cotton and are almost equal; they can spin up to 20's and the value is Rs. 320.

Tata's Allen's Hybrid and Allen Long Staple are superior to the last. They can spin up to 22's and the value is Rs. 335. Texas long staple selected for quality can spin up to 16's and is valued at Rs. 315; that selected for quantity can spin up to 20's and the value is Rs. 325. Boyd's Prolific is equal to good ordinary saw-ginned; can spin 16's, value Rs. 312,

The cross *Christopher* × *Culpepper* stands highest in value. It is a good long stapled cotton but slightly weak in staple. It can spin up to 24's and is valued at Rs. 345.

Improved Cook and Improved Perry have both deteriorated and have very short and weak staple. They can spin 12's, value Rs. 300.

Cambodia ordinary can spin up to 20's and is valued at Rs. 325, and Cambodia selected can spin up to 16's and is valued at Rs. 310.

In the Gadag auction sale, the Cambodia cottons were graded in five classes according to the percentage.

The following are Messrs. Tatas' valuations on samples from these lots :—

" No. 2 with a percentage of 35·5 of the 2nd class is the best. It can spin up to 24's. Value Rs. 330.

No. 1 percentage 36·5 of 1st class
No. 3 percentage 34·5 of 3rd class
No. 4 percentage 33·5 of 4th class
} Can spin up to 20's. Value Rs. 320.

No. 5 percentage 32·5 of 5th class. Can spin up to 16's. Value Rs. 310."

The programme of future work should include selection of Dharwar-American for quality and yield.

There is a mixture of Dharwar-American and New Orleans throughout the tract. The latter is not so resistant to disease and climate as the former and the yield of the Dharwar-American is better. Dharwar-American gins 32 per cent. against about 29 in New Orleans. The substitution of a pure crop of Dharwar-American for the present mixture with New Orleans should be persevered with.

In Ranibennur Taluka Dharwar-American is almost pure. It seems to be very difficult to cross artificially Dharwar-American and Cambodia and only a small percentage of natural crossing occurred.

In Cambodia, care should be taken not to carry too far selection for quantity as there is a suspicion that the quality

is deteriorating. Amongst the introduced Americans Peerless with a percentage of 40 is promising, but Cook, Dickson, King's improved and Peterkin are too late for the tract.

Auction sales of Broach and Cambodia cottons at Dharwar and Gadag.

These were held on the 30th April and 14th May 1916, respectively, under the control the of the Agricultural Department.

13,000 lb. of Broach seed including 3,000 lb. fresh seed directly imported from Navasari and about the same quantity of Cambodia was distributed at the beginning of the season.

On account of war difficulties 20 per cent. of Broach seed was not utilized for sowing as the growers thought that the prices for cotton would rule low; a shortage in the area also occurred on account of a prolonged break in the rains; the standing crop in some places had therefore to be grubbed up for sowing wheat.

The season proved to be very unfavourable to the cotton crop in general and the average outturn of both the cottons stood roughly at 150 to 200 lb. per acre, on a par with the local cottons, Kumpta and Dharwar-American, which is borne out by the fact that only 4,000 *dhokadas* were received in the Dharwar market against an average of 20,000 per annum. (*Dhokada* = $\frac{1}{4}$ Naga, 1 Naga = 1,344 lb.)

488 *dhokadas* of Broach cotton and 722 of Cambodia were received at the depôts; these were arranged in classes of five different grades according to the high or low ginning percentage of lint to seed cotton.

The ginning percentage of Broach cotton ranged from 29·5 to 33·5 and that of Cambodia from 32·5 to 36·5.

At the sales Broach fetched Rs. 165 to Rs. 190 and Cambodia Rs. 195 to Rs. 220 per naga of 1,344 lb., indeed very good prices; the prices were offered on the ginning percentage as well as for quality. The quotations for Kumpta and Dharwar-American on the same day were Rs. 148 and Rs. 150, respectively.

A large quantity of Broach and Cambodia was disposed of privately by the cultivators as they could not afford to wait till the sales took place.

All the Broach cotton was purchased by Messrs. Tata & Sons and Cambodia by Messrs. Forbes, Forbes Campbell & Co. of Bombay. Both the Companies were thoroughly satisfied with the product and are anxious for the extension of these high grade cottons in this part of the Presidency and they are quite willing to purchase any quantity that is produced in the Division at rates 20 to 25 per cent. higher than those prevailing for Kumpta and Dharwar-American.

I have already expressed my views with respect to the prospects of these cottons in the Southern Division which have been fully referred to in the Annual Report of this section for 1914-15 and would wish to add the following :—

With regard to the quality of cotton, Broach and Cambodia in normal years almost equal Navasari cotton (the best cotton in India) and possess superiority in the ginning percentage over the local cottons—Kumpta and Dharwar-American.

The staple of exotics is cut in sawgins which is not a desirable thing. Messrs. Forbes, Forbes Campbell & Co. got Cambodia seed separated out under roller gins whereby the staple was thoroughly preserved.

India grows only a few varieties, which can be counted on the fingers, producing cotton capable of spinning higher counts. *Bani* in the Central Provinces and *Karungani* in the Madras Presidency are no doubt long stapled cottons but the per acre outturn and the percentage of cotton to seed are very low—factors not in their favour.

Broach and Cambodia are long stapled cottons, the fibres are strong and uniform, colour creamy white and they can spin 40's.

In some places Broach and Cambodia have established themselves. It is true that extension of these cottons can only be carried over to suitable places but so long as we can not put out on a field scale our selected Kumpta strain with

a good ginning percentage, it is desirable that the introduced cottons which have passed the experimental stage should receive support at the hands of the Department both for extension and disposal.

It does not seem to be an insurmountable difficulty to sow Broach cotton before *jowari* when the cultivators have appreciated the value of this cotton. They are shrewd people and know their interest better.

Again the Department is now well strengthened by the location of Agricultural Overseers who can efficiently manage the cotton work which falls in the months of April and May when the work in the district is slack.

Gujerat. Ahmedabad District. Messrs. Whittle & Co. complained that the cottons of this tract had deteriorated by fraudulent mixing and enquiry shows that several varieties of cotton are grown normally in this tract and that very special care will have to be taken to prevent the mixture complained of.

Surat Farm. The programme of work for next year on this farm will be as follows :

1. Unit selections of Selection 11, 1018-P.G. and 1027-A. L. F. developed after special selections will be tried on a field scale.
2. Analytical work of local cottons of Khandesh and North Gujerat.
3. Trial of typical varieties of the Presidency to test the ginning percentages.
4. Special enquiry on the cottons of the Ahmedabad District based on the information supplied by this office.

Distribution of seed of improved strains in the Surat District.

Pure farm-grown seed of improved strains is distributed in a block of six villages round about Surat which is styled as group I.

Mixture of seed of all the selected strains is distributed in four villages and is called group II.

During the year under report 27,000 lb. seed was distributed in both the groups. Owing to a prolonged drought the crop had to be grubbed up in some cases and its place taken by other crops. The actual area under improved seeds was 1,500 acres. In spite of a bad season the cultivators were satisfied with the outturn and the quality.

The scheme formulated by Mr. Bhimbhai, as president of the committee for the disposal of *kapas* of the improved strains, has been found to work extremely well and the growers are thoroughly satisfied with this arrangement. Cotton was disposed of in 5 lots and the prices realized ranged between Rs. 138 to 140 per *bhar* (924 lb.) of *kapas* against Rs. 121 to 131 of the local cotton. This means that the growers earned on an average Rs. 8 to 9 per *bhar* of *kapas* over the local cotton by growing improved strains.

It is interesting to note that a certain landlord has put out about 250 acres under improved seed (mixture of all the four strains) between Navapurpeth to Khundara on the Tapti Valley Railway where the Surat *Deshi* type is grown. The outturn and the quality of cotton satisfied the growers in spite of a bad season. During the ensuing year he proposes to extend the area and he is said to have already secured 30,000 lb. seed for the purpose. From this it may be inferred that in such tracts improved strains will find a ready market without the intervention of Government. It is possible that improved strains may find way in places like Billimora, Chikhli, etc., where there is no severe competition of markets and where new seed is hardly introduced.

Broach. The percentage of the *ghogari* type has been found to increase rapidly as a mixture in the Broach type throughout the District. Towards Jambuser and from Chamargaon northwards it is impossible to find any field pure under the Broach type. This has resulted in the loss of the reputation of Broach cotton.

On the Government Plot pure Broach and the three *ghogari* types are tested to compare the outturn and the

ginning percentage with the prevailing mixture of Broach and Ghogari. This is the first year of the trials on a field scale with the *ghogari* types and as the character of the season was very unfavourable to the cotton crop it is premature to say anything on the relative merits of these types. The outturn results and the ginning percentage of each of the three types are almost equal this year. Pure Broach compares favourably in outturn with the *ghogari* type but its ginning percentage is low, being 38 against 44 of *ghogari*. The ginning percentage of all the cotton seems to be very high this year at the expense of quality. No doubt the *ghogari* type is superior in ginning percentage but the quality of cotton is inferior; in fact, it is Bengal cotton and can never be compared with *Broach*.

Dohad. This does not come within the actual zone of the cotton-growing tract. Trials were undertaken to test the behaviour of Bhuri, Cambodia, and N. R. one of the *neglectum* types, during the last five years with the result that the former two varieties were found quite unsuitable to this tract. They grew very vigorously during the early part of the season but later on they invariably suffered from attacks of pests and were destroyed by frost (the occurrence of which is common) as they occupied the ground for a longer period. It has, however, been found that N. R. cotton is the suitable variety for the black soil area though the period of maturity is rather prolonged on account of the retentive character of the soil. The percentage of cotton to seed is low, 36 against 38 on the Jalgaon Farm whence the seed is obtained.

In N. R. cotton, some plants produce perfectly naked seed, the naked seed type has been found to possess a very low ginning percentage—35 only though the fibre is good. The plants are dwarf in size and mature two weeks earlier than the ordinary N. R. It has been proposed to try this type on a fairly large scale during the ensuing year to test both outturn and ginning percentage results.

The area under cotton in these parts will be restricted as the soils can be double cropped. There is a difficulty

also in regard to the disposal of the produce at a reasonable price as there is no market for cotton.

Now that the appointments of Agricultural Overseers have been made for this tract it is hoped that energetic measures will be taken to steadily extend the area under cotton in different parts and show to the Bhils the relative advantages of this industrial crop; at the same time they will induce the merchants of Godhra to encourage cotton cultivation by paying reasonable prices.

Bengal and Assam.

Mr. Mankad undertook a tour to study the conditions under which cotton is cultivated in the Garo and the Chittagong Hill Tracts and submitted a report which was communicated to the local officers concerned.

Valuations. As usual all the samples received were submitted to Messrs. Tata Sons & Co., Bombay, to whom cordial acknowledgment is due for their kindness and promptitude in furnishing valuations and opinions of the numerous samples.

III. Programme of work for the year 1916-17.

Major.

(1) To visit and advise on points regarding cotton and its cultivation whenever requested to do so by the Provincial Departments of Agriculture.

Minor.

(2) The study of the behaviour of Bhuri, Cambodia and other such cottons in non-cotton-producing tracts as detailed in the last year's programme, will be continued.

(3) An enquiry into the manurial requirements of cotton will be continued.

(4) Researches on the botany of cotton will be continued.

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